Out-migrant Abundance Estimates and Coded Wire Tagging Pilot Study for Juvenile Salmonids at Caswell State Park in the Lower Stanislaus River, California

2007 Annual Data Report

Prepared by:

Clark B. Watry, Ayesha Gray, Ryan Cuthbert, Brian Pyper, and Kathryn Arendt

Prepared for:

U.S. Fish and Wildlife Service

Anadromous Fish Restoration Program

Grant No. 813326G008

CRAMER FISH SCIENCES

Corporate Office	Oakdale Office	Auburn Office	Idaho Office
600 NW Fariss Road	636 Hedburg Way, #22	1119 High Street, #2	121 W. Sweet Ave., #118
Gresham, Oregon 97030	Oakdale, CA 95361	Auburn, CA 95603	Moscow, ID 83843
(503) 491-9577 ׀ (877) 977-0102	(209) 847-7786	(530) 888-1443	(208) 883-9730

Table of Contents

Table of Figures

List of Tables

Summary

Rotary Screw Trap Operations

In 2007, we continued to monitor the juvenile salmonid out-migration at Caswell Memorial State Park (Caswell) at river kilometer (rkm) 13.8 on the lower Stanislaus River. Operations have occurred annually at this site since 1996 to estimate abundance of out-migrating juvenile Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead/rainbow trout (*O. mykiss*). We used three Rotary Screw Traps (RST), two were configured side-by-side and one was located approximately 100 m downstream, to capture out-migrants between January 12 and June 22, 2007. We developed abundance estimates for Chinook salmon by measuring trap efficiency, whereby a known number of marked fish were released upstream of the traps and compared to the number of recaptured marked fish. A predictive model was developed which used efficiency data from previous years and the nine efficiency tests from 2007 to determine daily trap efficiency. The abundance estimate of juvenile Chinook salmon passing Caswell between January 12 and June 22 was 94,411 (95% Confidence Interval of 66,428 to 122,394). The estimated abundance by life stage was 21,122 fry; 40,476 parr; 32,813 sub-yearling smolts; and, 357 yearling smolts. Fry were captured between January 12 and April 2, parr between February 23 and April 26, sub-yearling smolts between March 17 and June 22, and yearling smolts between February 24 and April 23. Two distinct migration peaks occurred this season; during a March 1 flood control release (n = 399 fry), and during an April 21 controlled flow increase from Goodwin Dam for the Vernalis Adaptive Management Plan (VAMP) (n = 330 smolts). Passage timing for parr and yearlings did not have discernible peaks. Mean fork lengths (FL) were 35 ± 0.3 mm for fry, 69 ± 1.5 mm for parr, 80 ± 0.4 mm for sub-yearling smolts, and 134 ± 8.1 mm for yearling smolts. In 2007, we captured one *O. mykiss* fry (30 mm FL), and 22 smolts with a mean FL of 224 ± 9 mm.

Coded Wire Tag Pilot Study

We implemented the pilot of a multiple year coded wire tag (CWT) study in 2007 at the Caswell monitoring station. We released 839 juvenile Chinook salmon with coded wire tags (656 fry with half-tags and 183 smolts with sequential tags) from February 26 and May 18. Average fry FL for fish captured in the traps during periods of CWT marking was 35.2 ± 0.3 mm, while average smolt FL was 82 ± 6.5 mm. Three juvenile Chinook salmon CWT tagged at the Caswell RST were recovered between April 1 and April 27, 2007. Two of these fish were recovered in the Mossdale trawl while the other was recovered at a CVP south delta pump. Columnaris (*Flavobacterium columnare*) infections observed during the season were an important factor affecting operations and procedures. Columnaris infections have not been thoroughly documented for the Stanislaus River, and continued work with the USFWS CA-NV Fish Health Center during the 2008 field season will assess the prevalence of infection and possible related factors on the Stanislaus River.

Introduction

The San Joaquin River and its tributaries, located in California's Central Valley, once contained Chinook salmon (*Oncorhynchus tshawytscha*) runs numbering in the hundreds of thousands (Yoshiyama et al. 2001). These runs historically demonstrated rich ecological diversity with representatives of various life history patterns present year-round. Central Valley Chinook salmon stocks have experienced unprecedented abundance declines, largely due to the onset of gold mining in the mid-19th century. Other factors affecting these runs included gravel mining, over-harvest, logging, hydropower development, agriculture, and corresponding urban development (Nehlsen et al. 1991; Yoshiyama et al. 2001; Williams 2006). Around the turn of the 19th century, hatchery supplementation was considered an adequate surrogate for wild fish displacement, but this only compounded the problem by compressing run timing and stock complexity (Augerot et al. 2005). Furthermore, spring-run Chinook salmon were historically the dominant race in the San Joaquin River and its tributaries due to unfettered access to high-gradient reaches in the upper watersheds. However, dam construction has prevented passage to these critically important staging areas and spawning grounds, and now the spring-run life history pattern has been considered extirpated from this region (Yoshiyama et al. 2001; Williams 2006). The Stanislaus River, a major tributary to the San Joaquin River, still provides valuable spawning and rearing habitat for Central Valley Chinook salmon, considered a species of concern under the federal Endangered Species Act (U.S. National Oceanic and Atmospheric Administration 2004).

The 1992 Central Valley Project Improvement Act (CVPIA) granted authority to the U.S. Fish and Wildlife Service (USFWS) to develop and implement a series of restoration programs, with the goal of doubling the natural production of anadromous fish in Central Valley streams. The U.S. Bureau of Reclamation (BOR) and USFWS are responsible for implementing provisions outlined in the CVPIA (available: http://www.usbr.gov/mp/cvpia/title_34/index.html). To support this goal, USFWS established the Anadromous Fish Restoration Program (AFRP) and the Comprehensive Assessment and Monitoring Program (CAMP). These programs set anadromous fish production targets, recommended fishery restoration actions for Central Valley streams, and formed a juvenile Chinook salmon and steelhead (*O. mykiss*) monitoring program to assess the relative effectiveness of fishery restoration actions. The two programs support informed feedback on population dynamics of target species that allow adjustments or improvements to adaptive management plans and approaches. Moreover, BOR is currently developing a Revised Plan of Operations (RPO) for New Melones Reservoir, located in the upper Stanislaus River drainage, to "…reduce the reliance on New Melones Reservoir for meeting water quality and fishery flow objectives, and to ensure that actions to enhance fisheries in the Stanislaus River are based on the best available science (P.L. 108-361)." One component of the RPO is to develop an instream fishery flow schedule for the lower Stanislaus River; however, insufficient information exists relating to juvenile salmonid survival, growth, migration timing, and the relative contribution of different life stages to provide a basis for determining the optimum flow timing and magnitude needed for out-migrating juvenile salmonids.

Our project objectives are to provide information on juvenile Chinook salmon abundance, migration timing, and relative contributions of different life stages to the returning adult population. This annual report details results from 2007 RST operations at Caswell Memorial State Park in the lower Stanislaus River and the associated pilot year of coded wire tagging (CWT) operations in the first and second sections, respectively. This juvenile salmon monitoring and tagging program helps AFRP and CAMP address their goals to track population dynamics, evaluate the results of past and future habitat restoration efforts, and to understand the impacts of instream flow schedules and management on the Chinook salmon population.

Study Area

The Stanislaus River, a major tributary to the San Joaquin River, flows southwest from the western slopes of the Sierra Nevada Mountains with a drainage area of approximately 240,000 ha and approximately 40% of its basin above snowline (Kondolf et al. 2001). The confluence of the Stanislaus and the San Joaquin rivers is located near the southern end of the Sacramento-San Joaquin Delta. The basin has a Mediterranean climate with dry summers and about 90% of the annual precipitation occurs between November and April (Schneider et al. 2003). More than 40 dams exist on the Stanislaus River. Collectively, these dams have the capacity to store 240% of the average annual runoff in the basin. Approximately 85% of this total storage capacity is in New Melones Reservoir (Schneider et al. 2003). Dams control the Stanislaus River for flood protection, power generation, irrigation and municipal water. The river is also used for whitewater recreation and off-channel gravel mining. Goodwin Dam, located at river kilometer (rkm) 94 of the Stanislaus River (measuring from the confluence with the San Joaquin River), is the upstream migration barrier to adult Chinook salmon (Figure 1). Most of the spawning in the Stanislaus River occurs in the 29 km reach below Goodwin Dam; however, spawning has been observed as far downstream as the City of Riverbank (rkm 53.1) (Pyper and Simpson, in prep).

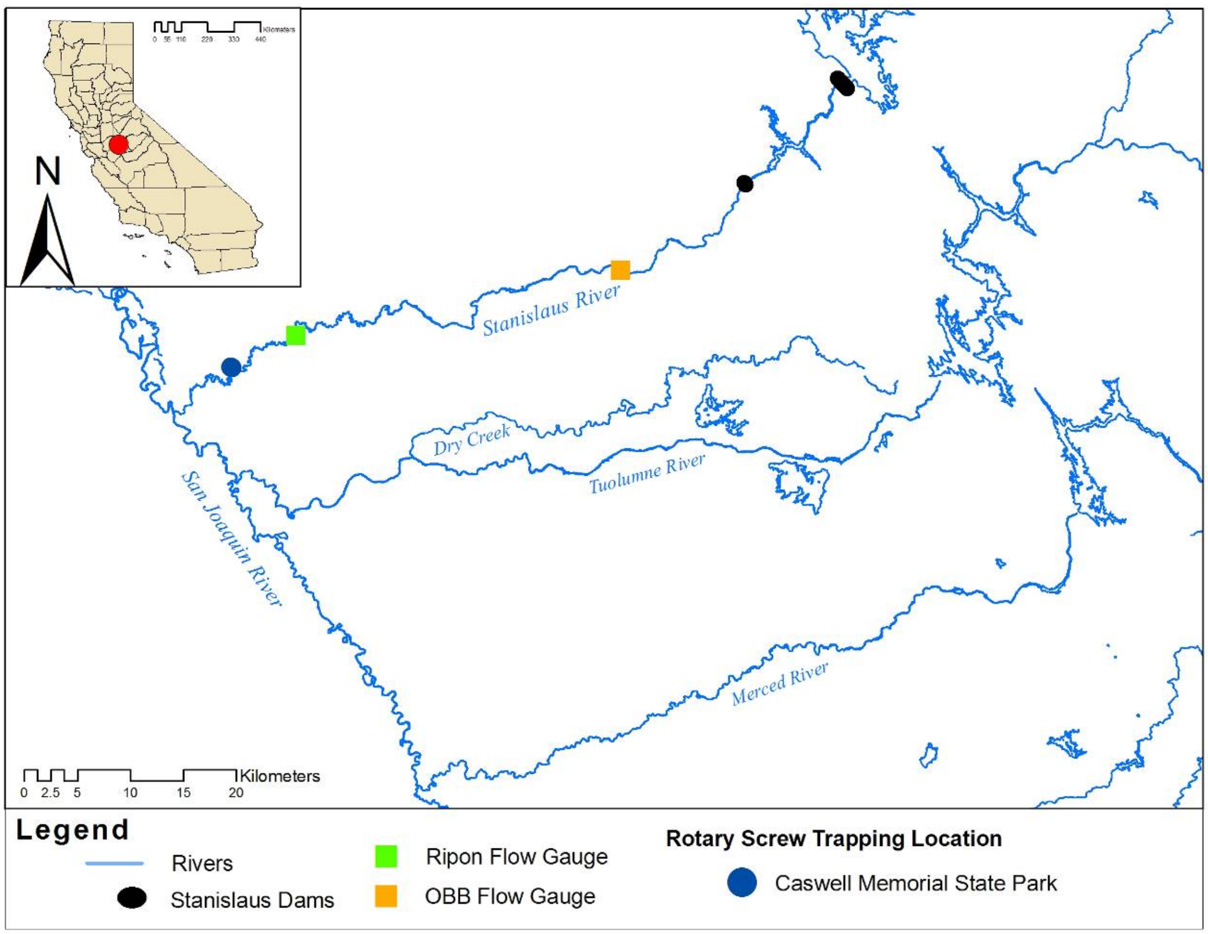

Figure 1. Map of the Stanislaus River below Goodwin Dam with landmarks.

Section 1: ROTARY SCREW TRAP OPERATIONS

Introduction

The U.S. Fish and Wildlife Service have supported a juvenile salmonid out-migration monitoring program in the Stanislaus River since 1995. The current monitoring program determines annual juvenile Chinook salmon and *O. mykiss* production using RSTs at Caswell Memorial State Park (Caswell) (rkm 13.8), and quantifies emigrants to the San Joaquin River. This long-term data set provides a valuable source of information for evaluating fish responses to in-river management actions.

The primary objectives for this project were to:

1. Estimate abundance of juvenile salmonid out-migrants in the lower Stanislaus River using RSTs operated near Caswell; and,
2. Determine and evaluate patterns of timing, size, and abundance of juveniles relative to flow and other environmental conditions.

Methods

Trap Operations

We used two side-by-side EG Solutions, Inc. RSTs (2.4 m diameter) in the mainstem Stanislaus River at Caswell (Figure 1.1, left). This site was selected as the furthest downstream location with suitable channel characteristics and adequate access to install and monitor two traps. At this location, the river is approximately 24 to 30 m wide and 1.5 to 4.6 m deep, depending on flow. As in previous years (Demko and Cramer 1997, 1998; Demko et al. 1999a, 1999b) the traps were oriented adjacent to a sandbag wall, (roughly three meters tall extending two meters from the north bank) created in 1996, to divert flow into the traps and increase trap rotations. Depending on flow, the center of the north trap was located 2 to 4 m from the north bank with the south trap alongside. In addition to the original trapping location, we added a third trap (lower trap) approximately 100 m downstream to attempt to increase total catch for the CWT project (see Section 2). Depending on flow the center of the lower trap was positioned 3 to 4 m from the north bank using the same cabling design as the north and south traps (Figure 1.1, right). The traps were strategically positioned to operate in the thalweg of the river channel where water velocities were greatest. Similar to our primary objective, Thedinga et al. (1994) used RSTs to determine the number of salmonid smolts that migrated from the Situk River, Alaska. We sampled 147 of a possible 162 days during the migration periods (January to June 2007) for Chinook salmon and *O. mykiss* on the Stanislaus River.

Figure 1.1. The north and south rotary screw traps (left), and the third rotary screw trap (right) at Caswell State Park (rkm 13.8). Upstream side-by-side traps are visible in the background (right).

Safety Measures

Staff members were trained in RST operational safety. We also posted safety precaution signage to warn river users and park visitors of the inherent dangers of the RSTs. We placed signs in conspicuous places at the trap site and on each side of the trap, to warn people of drowning danger as well as "Keep Out" and "Private Property" signs. A warning sign strategically placed upstream of the trap stated "Danger Ahead - Stay Left" with a large arrow pointing in the direction of the best side of the river channel for boaters to pass the traps. Flashing lights and flagging were placed on the traps and along the rigging. All signs were in English and Spanish.

Fish Capture and Handling

We checked the traps once a day during the morning hours, but occasionally, conditions required multiple trap checks per day (i.e., when large debris loads resulted from freshets or during scheduled releases from New Melones). We followed the RST protocol (Gray et al. 2007a) and established fish handling procedures. We used tricaine methanesulfonate (Western Chemical, Inc.; Tricaine-S) to anesthetize fish for safe handling. Up to 50 juvenile Chinook salmon per day were enumerated and measured for fork length (mm FL) and total length (mm TL), and up to 75 juveniles per week were weighed (g) using an Ohaus Navigator Scale (Model NOB110). We also collected scale samples from up to 50 Chinook salmon each week and catalogued them for future reference. We determined the smolt index, using the rating system developed by CDFG, for each Chinook salmon and *O. mykiss* sampled (Table 1.1), however we omitted smolt index 4 for Chinook salmon. We enumerated all other species, and determined length and weight of up to 20 fish of each species per day.

Table 1.1. Smolt index rating adopted from CDFG.

Smolt Index	Life Stage	Criteria
1	Yolk-sac fry	-Newly emerged with visible yolk sac
2	Fry	-Recently emerged with sac absorbed; Pigment undeveloped
3	Parr	-Darkly pigmented with distinct parr marks; No silvery coloration; Scales firmly set
4*	Silvery parr	-Parr marks visible but faded or absent; Intermediate degree of silvering
5	Smolt	-Parr marks highly faded or absent; Bright silver or nearly white coloration; Scales easily shed; Black trailing edge of caudal fin; More slender body
	Yearling-smolt	-All the same characteristics as a smolt; Generally larger than 110 mm FL

*Silvery parr life stage was only used for *O. mykiss*.

In 2007, we encountered periods of apparent poor juvenile Chinook salmon health. During these periods, we adjusted our protocol as follows: 1) measurement data and scale samples were not collected for live fish, and 2) fish specimens (dead or nearly dead) were fixed for histological analysis using Davidson's Fixative (0.82% formaldehyde; manufactured by Poly Scientific) and then stored in 70% isopropyl alcohol. We sent fixed samples to Scott Foott at the USFWS CA-NV Fish Health Center in Anderson, CA for analysis. We also added a gill coloration rating to our operations protocol, as gill color is an important indicator of fish health (S. Foott, USFWS CA-NV Fish Health Center, personal communication). We rated gills on a 1 (pale pink) to 5 (dark red) scale (Figure 1.2).

Figure 1.2. Technician inspecting juvenile Chinook salmon gills for coloration rating. Note: Photograph is a descriptive example using a dead fish.

Environmental Variables

We measured physical variables daily. We measured instantaneous water velocity using a Global Flow Probe (Global Water; Model FP101). Instantaneous turbidity was measured in Nephelometric Turbidity Units (NTU) using a turbidity meter (LaMotte; Model 2008). We recorded instantaneous water temperature and dissolved oxygen using an YSI Handheld Dissolved Oxygen Instrument (Model 550A). We obtained average daily flow data from three U.S. Geological Survey (USGS) gauging stations from the California Data Exchange Center (CDEC), including Goodwin Dam (GDW; rkm 94), Orange Blossom Bridge (OBB; rkm 75.5), and Ripon (RIP; rkm 25.4). We determined trap effort by measuring the rate of cone revolution during each trap check and recording the number of revolutions between checks from counters.

Trap Efficiency and Passage Estimates

Following methods from previous years, we conducted mark-recapture of juvenile Chinook salmon to estimate catch rate (trap efficiency) (Pyper and Simpson, in prep) and to develop a predictive logistic regression model to determine daily efficiency and estimate total juvenile salmonid passage.

Mark and Recapture

Fish were dye-marked using a photonic marking gun (Meda-E-Jet; Model A1000) with either green or pink dye on the caudal fin (Figure 1.3). Fish were released approximately 1000 m upstream of the traps after dark in small groups to prevent schooling. We processed the traps one hour after fish were released to check for immediate recaptures, additional recaptures were recorded with subsequent trap checks.

Figure 1.3. Technician marking fish (left) and marked fish (right).

Estimating Daily Trap Efficiency

We used logistic regression to develop models for predicting daily trap efficiencies at the Caswell site as a function of environmental conditions. The approach used all years of available data when developing the models. Specifically, a total of 137 experimental mark-recapture release groups across years 1996 to 2007 were used to estimate trap efficiencies at Caswell (Table 1.2).

Table 1.2. Summary by year of mark-recapture release groups at the Caswell trap site.

Year	Release Groups	Average Number Released
1996	8	2720
1997	2	3391
1998	7	2714
1999	8	1964
2000	15	1011
2001	12	1085
2002	11	800
2003	35	109
2004	8	255
2005	16	238
2006	6	1017
2007	9	77

In brief, logistic regression is a form of generalized linear model that is applicable to binomial data (McCullach and Nelder 1989; Dobson 2002).Here, the binomial probability of interest is the observed trap efficiency (q):

(1) $$q = \frac{c}{R} ,$$

where c is number of observed recaptures (a binomial variable) of a given release group of size R. The logistic model with n explanatory variables (x) can be expressed in linear form as:

(2) $$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_n x_n ,$$

where y is the "logit" transform of the observed trap efficiency (q):

(3) $$y = \text{logit}(q) = \log\left(\frac{q}{1-q}\right) .$$

The coefficients (β), which are estimated via maximum likelihood, provide predicted values of catch rate via the following back-transformation of the logit function:

(4) $$\hat{q} = \frac{\exp(\hat{\beta}_0 + \hat{\beta}_1 x_1 + \ldots + \hat{\beta}_n x_n)}{1 + \exp(\hat{\beta}_0 + \hat{\beta}_1 x_1 + \ldots + \hat{\beta}_n x_n)} .$$

We examined the following explanatory variables (x) for trap efficiency: flow, turbidity, and length (average fish length at release). We used the natural logarithm of flow, denoted log(flow), which had a roughly linear relationship with y (=logit(q)). We also examined the categorical variable year, which allowed for potential differences in mean trap efficiency among years that might arise due to annual changes in channel morphology, bank vegetation, predator abundance, trap placement, etc.

Our approach was to fit logistic models using all years of available data. This approach assumes the relationship between trap efficiency and an explanatory variable such as flow will have a similar form across years. An alternative would be to fit models separately to each year of data, but this potentially allows relationships to differ appreciably among years (e.g., a positive effect of flow in one year, but a negative effect in a different year). Such differences would likely have little biological support and would be considered spurious. In contrast, modeling all years simultaneously provides fewer models and more data, which reduces the chance of finding spurious relationships and increases the statistical power to detect relationships that have a consistent basis across years.

The statistical significance of explanatory variables was tested using analysis of deviance (McCullach and Nelder 1989; Venables and Ripley 1999).Under the binomial assumption, a logistic model that adequately explains variability in trap efficiencies will have a deviance roughly equal to the residual degrees of freedom. However, in our analyses, model deviances were much greater than that expected due to binomial sampling error alone. Such extra-binomial variation, which may arise from either over-dispersion or inadequate model structure (i.e., when key processes affecting trap efficiencies are missing from the model), must be accounted for when testing variables and estimating confidence intervals. Extra-binomial variation is represented by a dispersion parameter, Φ, which is a scalar of the assumed binomial variance. To conduct statistical tests and compute confidence intervals, we multiplied the variance-covariance matrix for the logistic coefficients by the dispersion parameter, which is easily estimated from the fit of a logistic regression (Venables and Ripley 1999).

Passage Estimates

The daily passage abundance (*n*) of migrating juvenile Chinook salmon was estimated as follows:

(5) $$n = \frac{c}{q} ,$$

where *c* was observed daily count and *q* was the estimated trap efficiency for that day based on the "preferred" logistic model for a given trap site (discussed below). Annual passage was estimated by summing the daily abundance estimates. Standard errors (SE) and confidence intervals for measures of cumulative daily abundance and total annual abundance were computed using methods described in Demko et al. (2000).

During the 2007 migrations, there were periods when traps were not fished. To estimate a missing value of daily count (*c*) within a sampling period, we used the weighted average of all observed counts for the five days before and five days after the missing value (Demko et al. 2000). The weights were equal to one through five, where values that were directly adjacent to the missing day were weighted as five, values that were two days before and after the missing day were weighted as four, and so on. This weighted average was reasonably effective at capturing the temporal trends in daily counts observed across years.

Results

Trap Operations

We began our sampling effort immediately following trap installation (January 12) and ended operations on June 22, 2007. During periods when daily catch was consistently low, we sampled 4 days a week, which resulted in 147, out of a possible 162, trapping days. Our sampling on the Stanislaus River encompassed out-migration periods for age-0 fry, parr and smolts, and age-1 yearling smolts.

Catch and Environmental Variables

During the 2007 trapping season, we captured a total of 2,909 juvenile Chinook salmon (Figure 1.4). Flow at RIP during the year ranged from 472 to 1,488 ft^3/s which directly reflected controlled releases from GDW. Two peaks in daily catch occurred during the trapping season resulting in 399 Chinook salmon captured during a flood control release on March 1, and 330 Chinook salmon captured during a controlled increase from GDW for the Vernalis Adaptive Management Plan (VAMP) on April 21 (Figure 1.4). The first peak also coincided with a peak (10.8 NTU) in instantaneous turbidity due to a precipitation event (Figure 1.5). Water temperature at Caswell gradually increased from 6.9°C to 21.4°C, and catch at Caswell drastically decreased when temperatures increased above 20°C (Figure 1.6). Conversely, water temperature at OBB, rkm 61.6 upstream of RIP, never increased above 15.7°C.

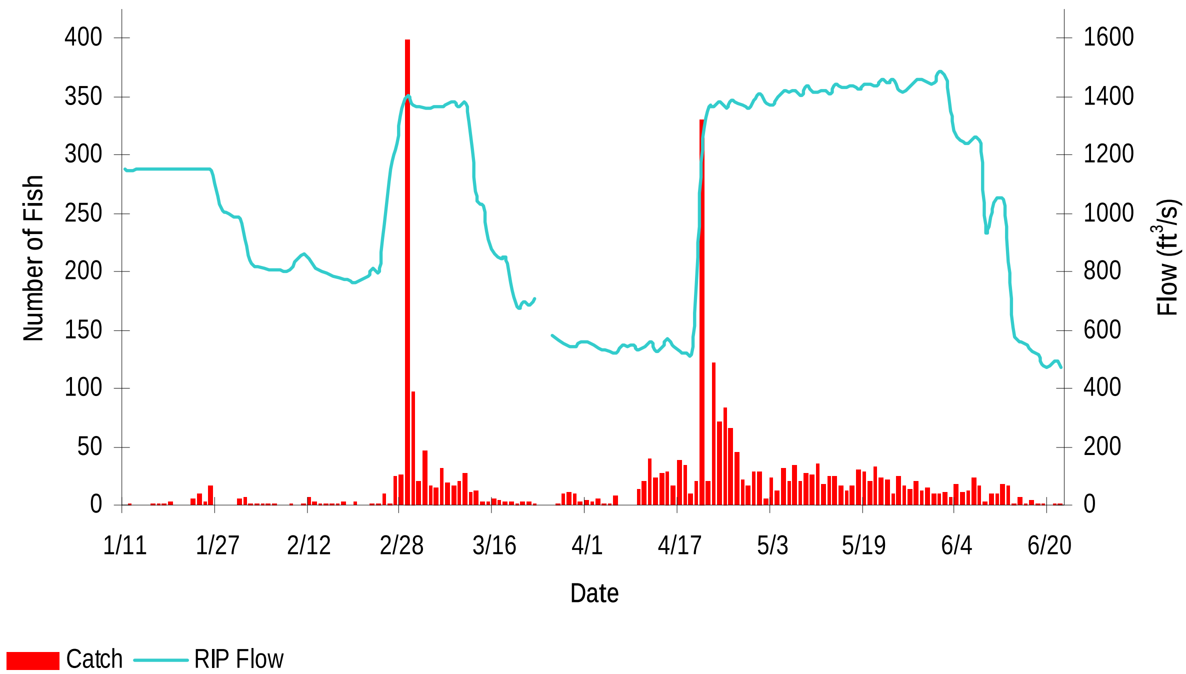

Figure 1.4. Daily Chinook salmon catch and flow at RIP, 2007.

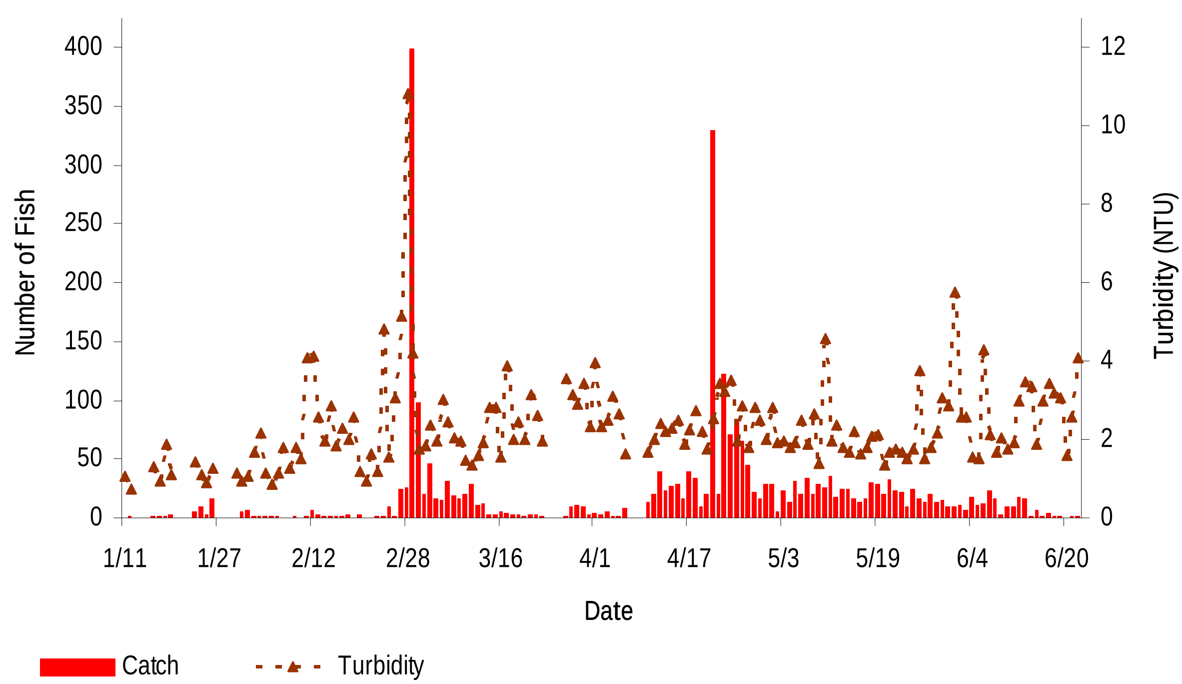

Figure 1.5. Daily Chinook salmon catch and instantaneous turbidity at Caswell, 2007.

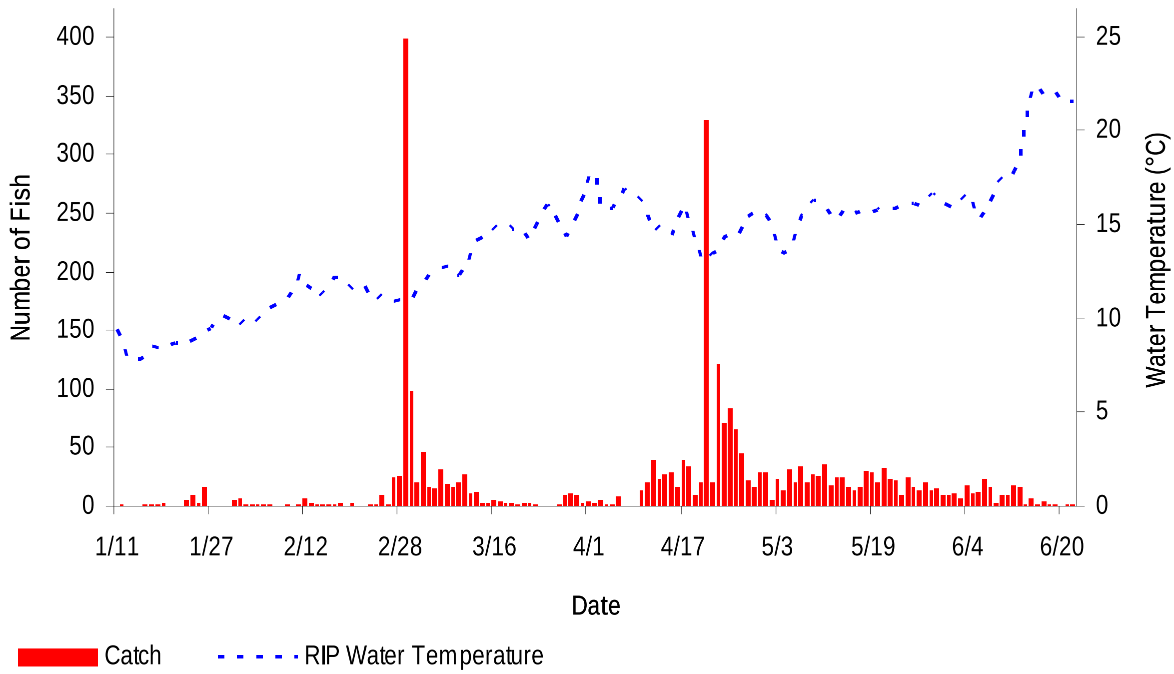

Figure 1.6. Daily Chinook salmon catch at Caswell and average daily water temperature at RIP, 2007.

We caught 34% (n = 990) and 37% (n = 1,076) of the Chinook salmon total catch in the north and south traps, respectively. The lower trap accounted for 29% (n = 843) of the total Chinook salmon catch (Figure 1.7).

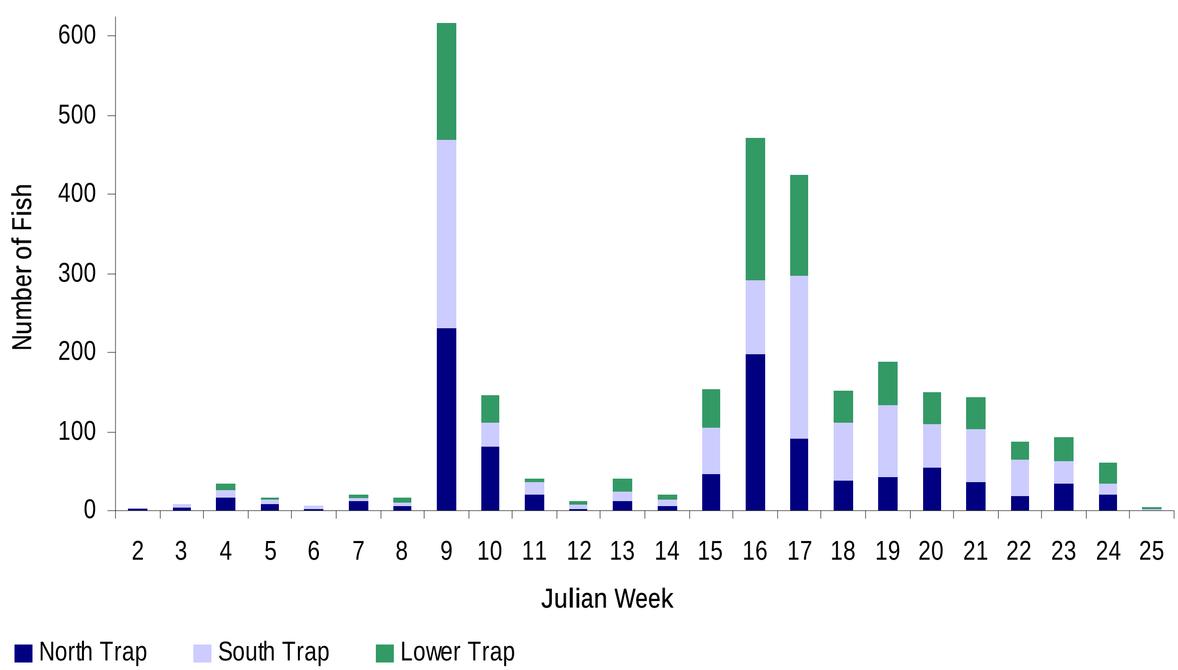

Figure 1.7. Contribution of the north, south, and lower traps to the total Chinook salmon catch by Julian week.

Our overall mortality rate was 3.4% (n = 100) of the total Chinook salmon catch. Daily mortality rates ranged between 0% and 50%. Peak mortality rates occurred between March 18 and April 2 during a period of extremely low catch numbers (Figure 1.8).

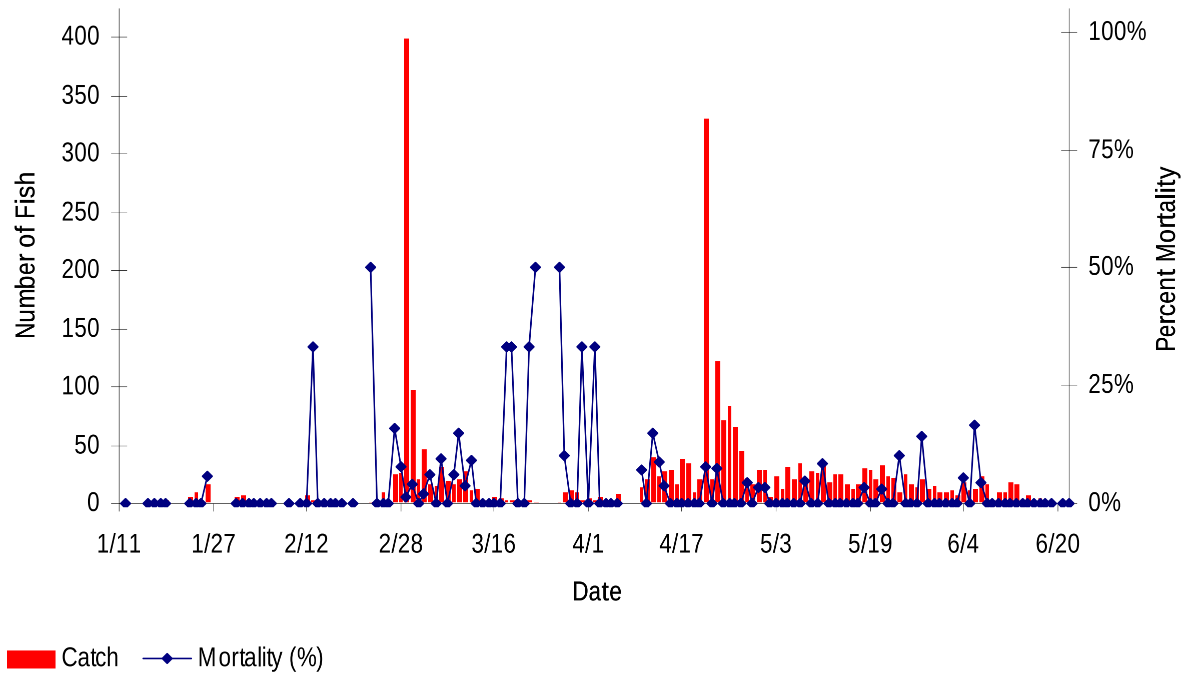

Figure 1.8. Daily Chinook salmon catch and percent mortality at Caswell, 2007.

We captured four juvenile Chinook salmon life stages, including fry, parr, smolt, and yearling-smolt emigrants between January 12 and June 22, 2007 (Table 1.3). The three life stages had different timing patterns and size distributions (Table 1.4; Figure 1.9–Figure 1.11) and mean FL was significantly different for all life stages (ANOVA: F = 8,374, $P < 0.0001$). Based on the length-frequency distribution, the 30- to 40-mm size classes were dominated by fry, the 65- to 75-mm size classes were dominated by parr, and the 75- to 85-mm size classes were dominated by smolts (Figure 1.9). We also caught 9 fish above 110 mm that represented the yearling-smolt life stage (Table 1.3 and Table 1.4; Figure 1.9 and Figure 1.10). Proportions of each life stage were compared to cumulative catch, and the fry and smolt catch closely corresponded with early and mid-season passage trends (Table 1.4; Figure 1.11).

Table 1.3. Percent of run and range of catch dates for each life stage of Chinook salmon.

Life stage	Number	Percent of Run	Date Range
Fry	904	35.0	Jan 12 – Apr 2
Parr	123*	4.8	Feb 23 – Apr 26
Smolt	1,546*	59.9	Mar 17 – Jun 22
Yearling-smolt	9	0.3	Feb 24 – Apr 23
Cumulative Total	2,582	100.0	Jan 12 – Jun 22

*During intermixed parr and smolt daily catches, 327 Chinook salmon were not rated for life stage.

Table 1.4. Median and peak Chinook salmon catch dates, and minimum, maximum, and average fork lengths (mm). Mean FLs were significantly different for the different life stages (ANOVA: F = 8.374, P < 0.0001).

Life Stage	Median Catch Date	Peak Catch Date	Peak Counts	Minimum FL (mm)	Maximum FL (mm)	Average FL (mm)
Fry	Mar 1	Mar 1	399	23	61	35 ± 0.3
Parr	Apr 16	Apr 26	19	40	99	69 ± 1.5
Smolt	Apr 29	Apr 21*	137	61	106	80 ± 0.4
Yearling-smolt	Mar 16	Mar 17	2	115	147	134 ± 8.1

*Total catch was 330 salmon and plus counted fish (n = 184) were intermixed parr and smolt for this date.

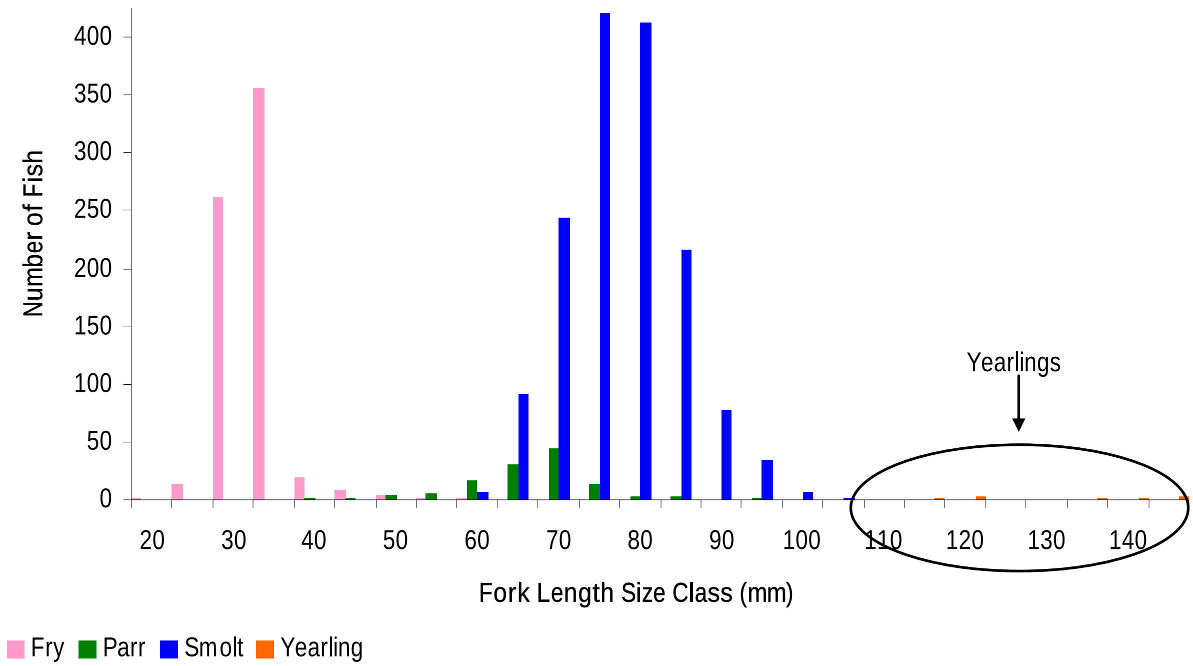

Figure 1.9. Fork length (mm) distributions for fry, parr, smolts, and yearling-smolts at Caswell, 2007.

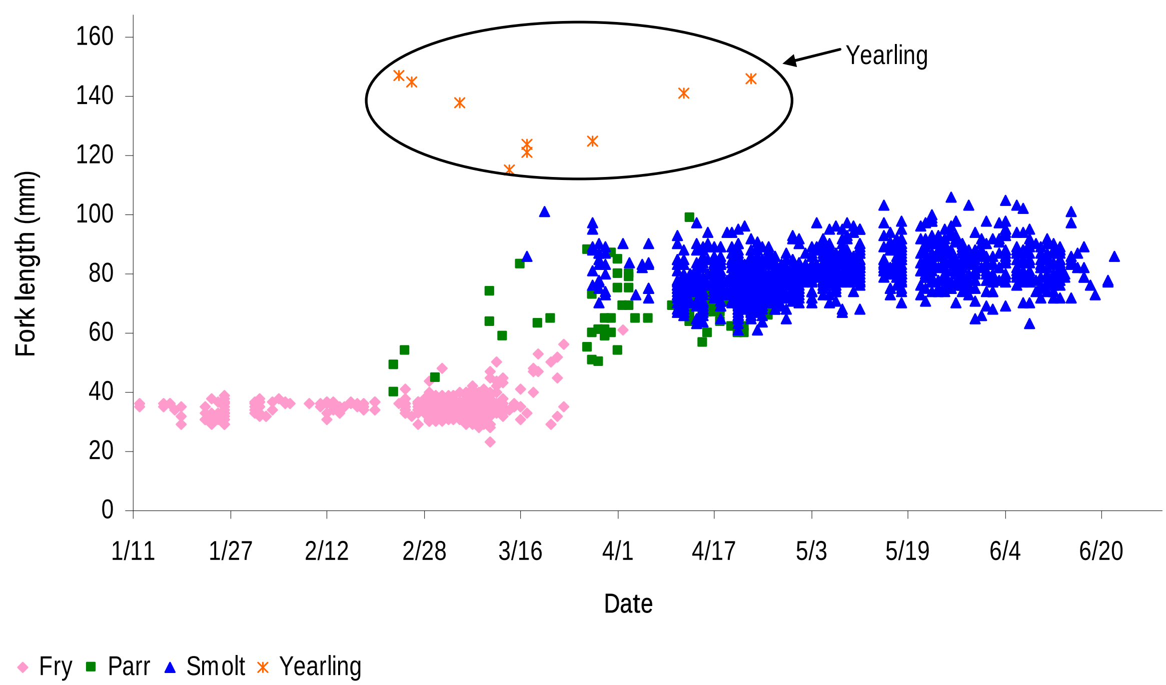

Figure 1.10. Fork length (mm) distributions for fry, parr, smolts, and yearlings at Caswell, 2007.

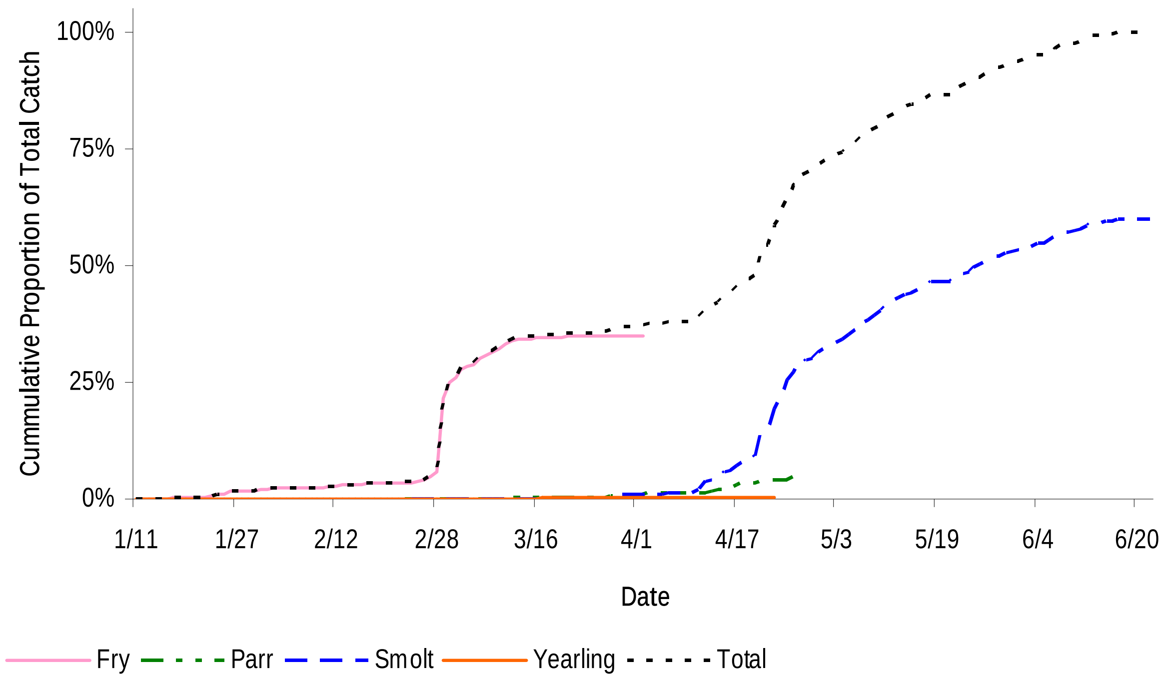

Figure 1.11. Cumulative proportions of total catch for fry, parr, smolts, and yearling-smolt Chinook salmon at Caswell, 2007.

Trap Efficiency and Passage Estimates

During the 2007 season, we conducted 9 marked releases to determine trap efficiency, and across years (1996-2007), there was a strong negative trend between trap efficiencies and flows at the Caswell site (Figure 1.12). A negative trend was also apparent between trap efficiencies and fish length. However, there was no obvious trend between trap efficiencies and turbidity (Figure 1.12).

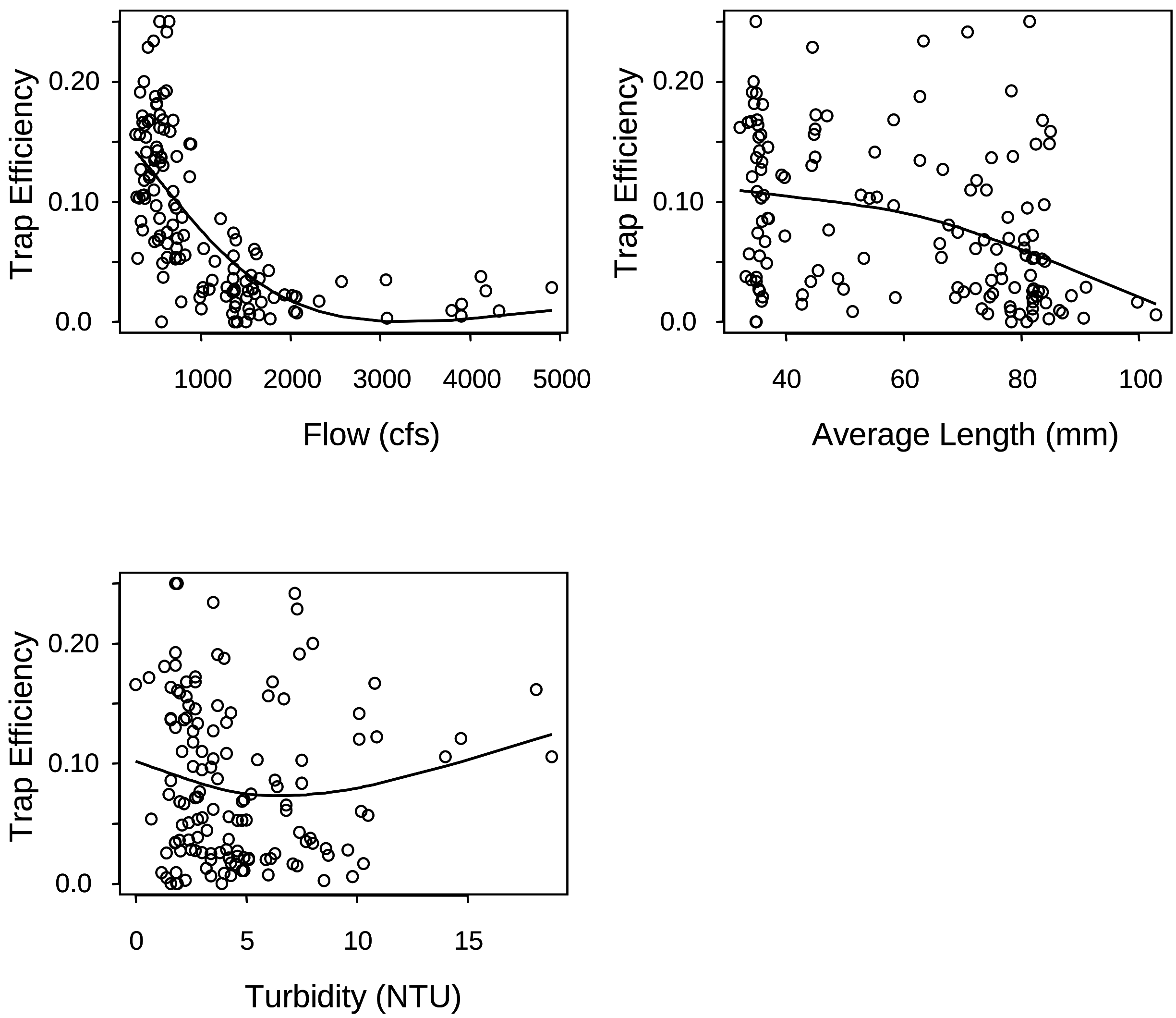

Figure 1.12. Trap efficiencies as a function of flow, fish length, and turbidity for the 137 mark-recapture releases at the Caswell trap location. Solid lines are exploratory fits of smoothing splines.

The logistic regression analysis indicated that trap efficiencies were significantly related to the variables log(flow), length, and year (Table 1.5 and Table 1.6; Figure 1.13). The dominant explanatory variable was log(flow), accounting for 68% of the total deviance (Table 1.6). Fish length at release, which accounted for 5.2% of the deviance, had a moderate negative effect on trap efficiencies. The categorical variable 'year' accounted for 6.5% of the deviance, and indicated that trap efficiencies during 2006 and 2007 were lower on average than during the previous five years 2001-2005 (Table 1.6; Figure 1.13). Adding the variable turbidity to the model did not improve the model fit (deviance explained = 0.7, $P = 0.78$).

Table 1.5. Regression coefficients and standard errors (SE) for the preferred logistic model fit to trap efficiencies of 137 mark-recapture releases at the Caswell trap site. Note the coefficient for 1996 is taken to be zero, whereas coefficients for 1997-2007 represent differences in logit(catch rate) relative to 1996.

Variable	Coefficient	SE
Intercept	2.61	0.86
log(flow)	-0.65	0.12
Length	-0.01	0.00
1997	-0.42	0.23
1998	-0.42	0.17
1999	-0.45	0.18
2000	-0.63	0.17
2001	0.07	0.18
2002	-0.08	0.19
2003	0.43	0.19
2004	-0.02	0.26
2005	-0.04	0.23
2006	-0.91	0.40
2007	-0.48	0.56

Table 1.6. Analysis of deviance for the logistic model fit to trap efficiencies of 137 mark-recapture releases at the Caswell trap site. Df = degrees of freedom.

Variable	Df	Deviance	Residual Df	Residual deviance	F Value	P-value
Intercept			136	4719.6		
log(flow)	1	3208.1	135	1511.5	391.8	<0.001
Length	1	243.9	134	1267.6	29.8	<0.001
Year	11	309.1	123	958.5	3.4	<0.001
Total	13	3761		958.5		

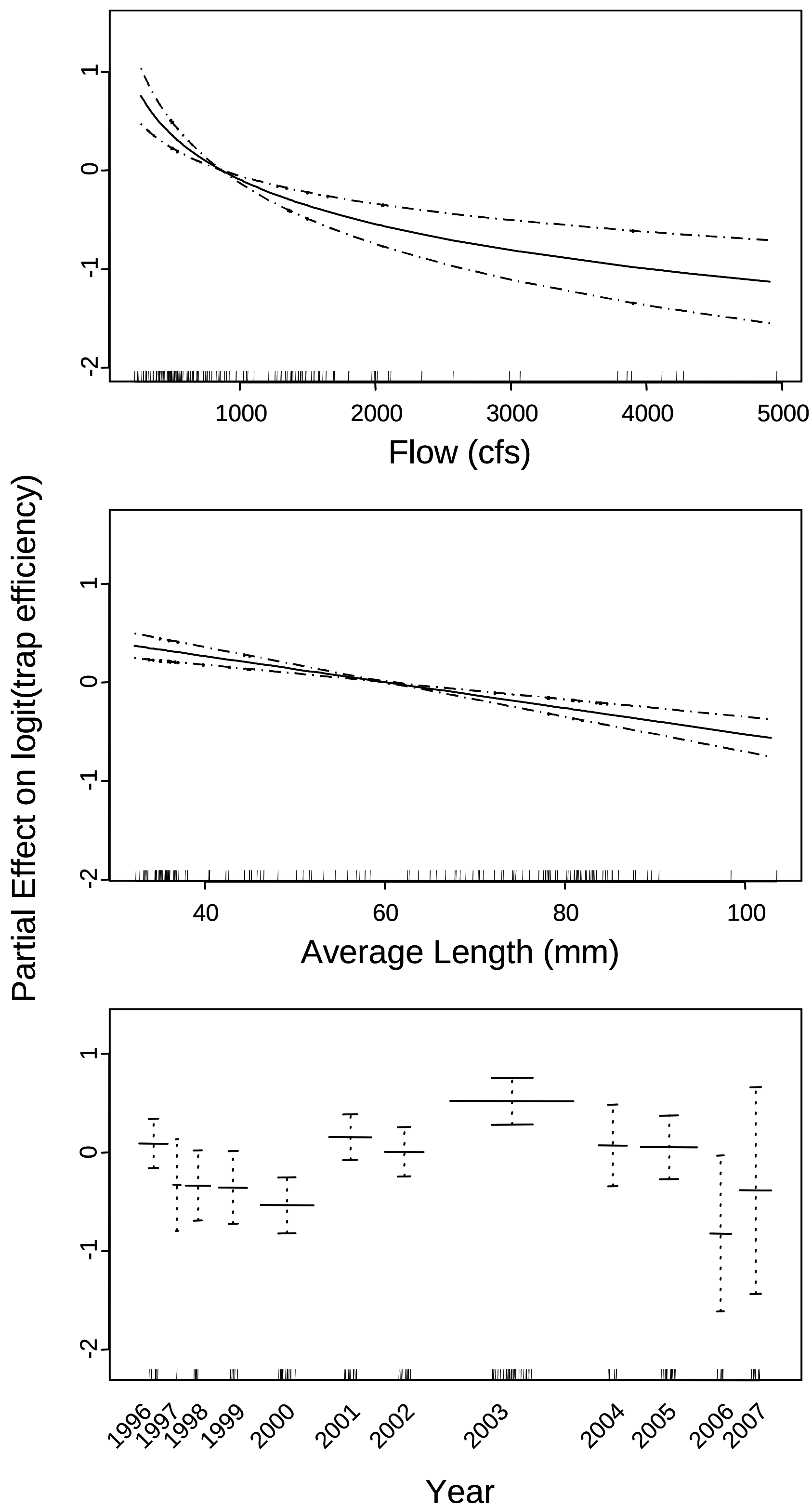

Figure 1.13. Partial effects of log(flow), length, and year on deviance residuals of logit(efficiency) for the Caswell trap site (1996-2007). Each plot has a similar scale for the Y-axis so that the relative effect of each variable can be compared. Dashed lines indicate approximate 95% pointwise confidence intervals. Tick marks on the X-axis show locations of trap efficiency estimates for a given variable.

Passage Estimates

Estimates of the total abundance of juvenile Chinook salmon passing the Caswell trap site in 2007 are presented in Table 1.7, and cumulative daily passage estimates are shown in Figure 1.14. The total passage estimate was 94,411 (95% CI: 66,428 to 122,394). The estimated precision (an indicator of reliability) and confidence interval for the total passage estimate for 2007 suggests that the estimate is reasonably precise (Table 1.7). The estimate of standard error (SE) provides an absolute measure of precision, while the coefficients of variation (CV = SE / Passage Estimate) provides a relative measure of precision. For 2007, the estimated proportions of the total Chinook salmon passage designated as fry (< 45 mm), parr (45-80 mm), and smolt (> 80 mm) were 22.4%, 42.9%, and 34.8%, respectively (Table 1.8).

*Table 1.7. Estimated total number of juvenile Chinook salmon passing the Caswell trap site, 2007. SE = standard error of the estimate. CV = coefficient of variation of the estimate, where % CV = (SE / Total Passage) * 100.*

Year	Total Passage	SE	Lower 95% CI	Upper 95% CI	CV
2007	94,411	14,277	66,428	122,394	15.1%

Table 1.8. Passage estimates for juvenile Chinook salmon by life stage at the Caswell trap site, 2007.

Year	Passage Estimate			Percent (%) of Total		
	Fry	Parr	Smolt	Fry	Parr	Smolt
2007	21,122	40,476	32,813	22.4%	42.9%	34.8%

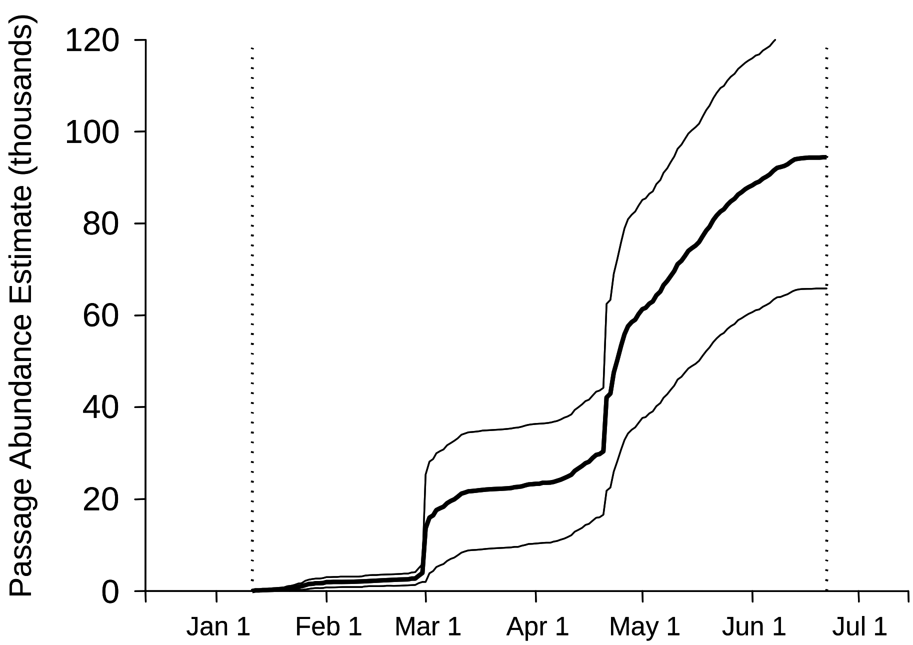

Figure 1.14. Cumulative passage estimates (bold line) at the Caswell trap site, 2007. Thin lines denote approximate 95% confidence intervals. Dashed vertical lines indicate start and end dates for trapping.

O. mykiss

We captured 23 *O. mykiss* during the trapping season. *O. mykiss* FL ranged from 30 to 285 mm with an average FL of 216 ± 19 mm. Our *O. mykiss* catch was dominated by smolts in the 220-mm size class, only one fry (30 mm FL) was captured (Figure 1.15).

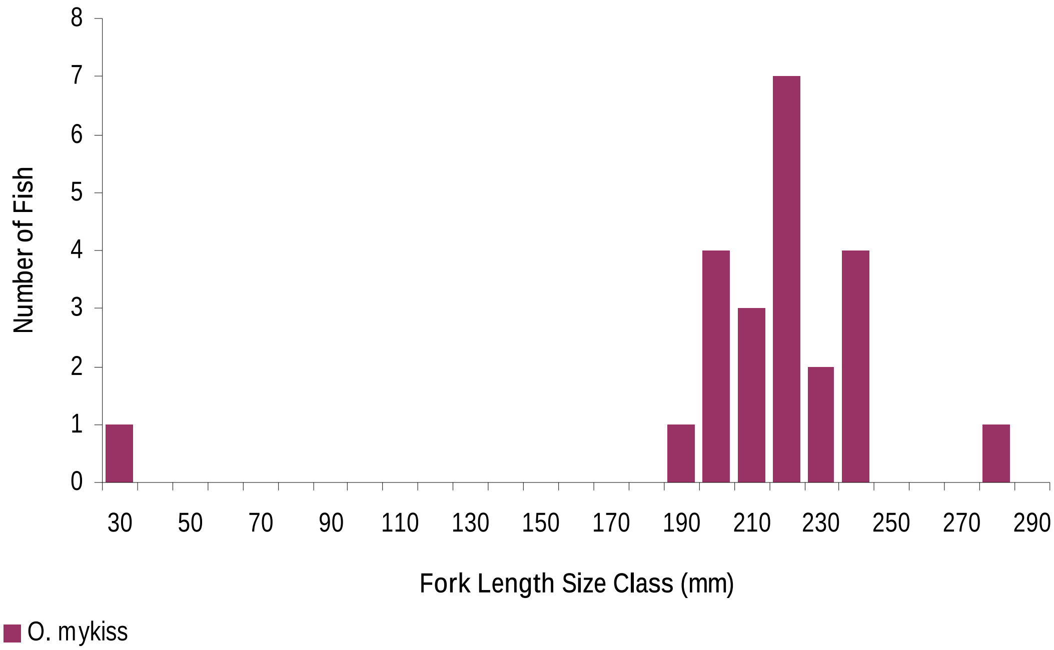

Figure 1.15. Fork length distribution for O. mykiss captured at Caswell, 2007.

Non-Target Species

We captured 690 incidental fish of 27 identifiable species (Figure 1.16). Due to the difficulty with speciation some juvenile fish in the field, we counted 502 unidentified lamprey (*Lampetra* spp.) and 132 Centrarchids. We identified 18 non-native incidental species, including 11 potential predators of juvenile Chinook salmon and steelhead (Figure 1.16; see Appendix 1: Species List, p. 40).

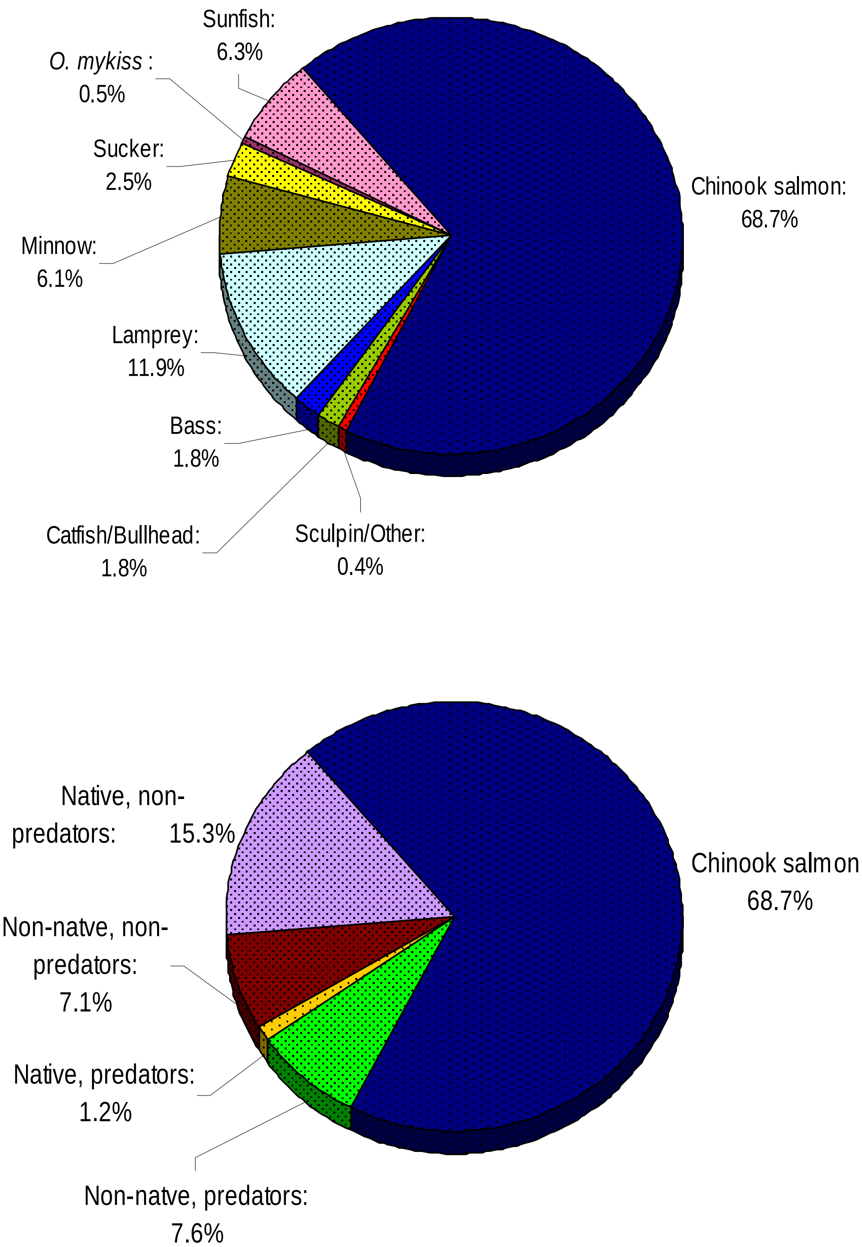

Figure 1.16. Upper: Relative abundance of all species captured at Caswell, 2007. Lower: Percent composition of native, non-native, predator, non-predator, and Chinook salmon catches at Caswell, 2007. Designation of native and predator status developed from Moyle (2002).

Discussion

In 2007, we continued juvenile Chinook salmon out-migration RST monitoring in the lower Stanislaus River at Caswell Memorial State Park (rkm 13.8). Operations have occurred annually at this site since 1996 to estimate abundance of out-migrating juvenile Chinook salmon and *O. mykiss*. We also conducted staff trainings, developed operational protocols, and documented abundance and timing patterns for juvenile Chinook salmon in the lower Stanislaus River. During the 2007 sampling season our catch (n = 2,909) and passage estimates (N = 94,411 ± 27,983) were lower than previous seasons and likely correspond to the 2006 adult Chinook salmon escapement total of 3,067 fish, also lower than previous year's measures (Anderson et al. 2007).

Flow, turbidity, and water temperature are all key factors affecting migration patterns of juvenile Chinook salmon (Holtby et al. 1989; Gregory and Levings 1996; Giannico and Healey 1998; Sommer et al. 2001). Although Central Valley rivers exhibit limited variability in these environmental conditions due to the profound influence of large, upstream impoundments, we observed peak catches that corresponded to changes in environmental conditions. For instance, increased fry catch occurred during a combined freshet/flood control release flow pulse on March 1, and increased smolt catch occurred on April 21 following the increased flow for VAMP. In both cases, peak catch occurred during the initial increase in flow and lasted for only a few days. Differing magnitude flow pulses have been found to stimulate juvenile Chinook salmon migration rates. Kjelson et al. (1981) found that peak catches in the Sacramento-San Joaquin Delta were often correlated with flow peaks caused by storm runoff. They suggested flow pulses stimulated fry to emigrate from spawning grounds; a finding supported by USFWS (2003). Turbidity and flow are related terms when evaluating migration triggers, as higher turbidity is usually caused by a freshet or increased flow. Several authors have found increased turbidity to reduce predation on resident and migrating young salmonids by providing a form of protective cover, enabling them to evade detection or capture (Gradall and Swenson 1982; Cezilly 1992; Gregory 1993; Gregory and Levings 1998). This phenomenon could contribute to higher in-river survival resulting in increased catch rates during periods of higher flows and increased turbidity.

Higher survival rates could also result from a favorable temperature regime that promotes optimal growth and fish health. Temperatures up to 19°C are favorable for optimal growth while cooler temperatures (i.e., 10°C to 17°C) during the parr to smolt transformation are thought to improve survival at ocean entry (Myrick and Cech 2001). Furthermore, Marine (1997) found that juvenile salmon reared under increasing temperature regimes displayed impaired smoltification patterns compared to the patterns observed under lower temperatures (13°C to 16°C). Although temperatures up to 19°C may promote growth, a slightly lower temperature profile during the smolt out-migration in late April and May could be more beneficial to the long-term survival of emigrating fish. Temperatures in the lower Stanislaus River in 2007 tended to approach 16°C during the smolt migration, particularly in May (see Figure 1.9). Several researchers have documented problems related to thermal stress (Coutant 1973; Baker et al. 1995), and it is generally accepted that increasing temperatures would adversely affect growth rates, fish health, and, consequently, survival.

The prevalence of different naturally-occurring fish diseases can increase with high water temperatures that promote disease outbreaks (Holt et al. 1975; Boles et al. 1988). Poor apparent fish health was observed at different times during the season, and high mortality rates (up to 50%) were suspected to result from columnaris infections (see Appendix 2 - Fish Health Report). Although we intermittently observed high catch mortality, our overall seasonal mortality rate was 3.8% of the total catch. This rate was substantially lower than the 9.5% fry and 32.7% smolt mortality rates reported by Johnson and Rayton (2007), but higher than the < 1% reported by Sparkman (2001) in similar studies. In the absence of columnaris infections, we assume our Chinook salmon trapping mortality would be considerably lower; however, the observed fish health problems highlight the need for additional study since little is known about the prevalence or factors causing infection on the Stanislaus River (S. Foott, CA-NV Fish Health Center, personal communication).

Age-0 Chinook salmon emigrate during various life stages (i.e., fry, parr, and smolt) in Central Valley rivers. We found four distinct life stages with significantly different mean FLs in the Chinook salmon catch on the lower Stanislaus River. Our catch was predominately fry (35%) and smolt (59.9%) in 2007. However, we also identified a small group (n = 9) of yearling-smolts (0.3%) emigrating past the traps. These strategies corresponded to distinct juvenile life history types identified by Reimers (1973) and Quinn (2005) whereby each distinct life history strategy exhibited different patterns of migration timing and habitat use (Table 1.9). The fry migrant strategy observed in the lower Stanislaus River is consistent with the Type-1 life history, while the smolt migrant strategy corresponds to either the Type-2 or -3 life histories. Furthermore, the yearling-smolt migrant strategy is consistent with the Type-5 life history. In contrast to the Stanislaus River, nearly half (44%) of the annual out-migrants from the main stem of the upper South Umpqua River basin, Oregon were between 50 and 59.9 mm FL and less than 10% of the fish out-migrated before they reached 50 mm or after they reached 80 mm (Roper and Scarnecchia 1998). These fish would be similar in size to fry and parr on the Stanislaus River. This example illustrates the extent of ecological plasticity in life history strategies utilized by the species. Understanding the relative contribution of these life history types to the overall adult production can help resource managers adapt their approaches to benefit salmon and still meet the needs of other resource users.

Table 1.9. Juvenile Chinook salmon life history types as described by Reimers (1973) and Quinn (2005).

Life History Type	Life History Description
Type-1	Fish migrated through the river and out to sea as newly emerged fry.
Type-2	Fish reared in the river or in it's tributaries until early summer, reared for a short time in the estuary, and moved out to sea in midsummer.
Type-3	Fish reared in freshwater until early summer and in the estuary until fall.
Type-4	Fish stayed in freshwater until fall and then migrated out to sea without significant use of the estuary.
Type-5	Fish spent a year rearing in freshwater and migrated directly to sea as yearling smolts.

This year we captured 22 *O. mykiss* smolts and 1 fry at Caswell which is the second largest total *O. mykiss* catch for a season at Caswell (Demko and Cramer 1997, 1998; Demko et al. 1999a, 1999b; Fleming 1997). Trout fry captures are rare and the only other year *O. mykiss* less than 50 mm were captured at Caswell was in 1996 (Demko and Cramer 1997). *O. mykiss* smolts may be migrating to the ocean, exhibiting anadromy; however, these fish could also migrate back upstream or into another tributary and assume a resident life history (Foss 2005).

Capture of non-target fishes may be important to understanding Chinook salmon and *O. mykiss* population dynamics, as non-native species may compete or prey upon juvenile salmonids. Our non-target species catch was composed of similar proportions of native and non-native non-salmonid species. May and Brown (2002) evaluated fish communities in Central Valley rivers, found a prevalence of non-native species in San Joaquin tributaries versus those of the Sacramento River, and suggested native fish populations resist invasion when more natural (instream water delivery) flow conditions are maintained. The relationship of flow to fish species assemblage is also documented in rivers (i.e., Feather River) with low relative abundance of non-native species (Seesholtz et al. 2004). Zimmerman (1999) found non-native predators out-compete native predators for food and resources. The prevalence of non-native species likely significantly impacts juvenile salmonid production.

Long-term operation of the Caswell RST sampling program provides valuable data on juvenile Chinook salmon and *O. mykiss* and broadens our understanding of salmonid population dynamics within the lower river. The results from the 2007 season provide additional information to AFRP and CAMP and help support fisheries management decisions for the Stanislaus River.

Section 2: CODED WIRE TAG PILOT STUDY

Introduction

In 2007, Cramer Fish Sciences (CFS) initiated the first year of a five-year coded wire tag study of juvenile fall Chinook salmon in the Stanislaus River under contract with AFRP and funded by BOR. The contribution rate of fry and parr out-migrants to the returning adult population is generally unknown, and management actions have focused on smolt survival in the absence of a thorough understanding of the importance of the different life history types to the overall population. Additional monitoring is required to determine the relative contribution to adult Chinook salmon by fry, parr, and smolts out-migrants in the Stanislaus River. By tagging fish based on their life stage (fry, parr, and smolts) and out-migration timing, we will obtain data to help us better understand the contribution rates of each life stage, and how the timing of spring flow releases may be improved to facilitate increased in-river survival and production of all juvenile Chinook salmon life stages.

The primary objectives of this project were to:

1. Determine the relative contribution rates of fry, parr, and smolts to the returning adult population;
2. Draw inferences on survival, growth, and migration timing for juvenile salmonids in the Stanislaus River;
3. Identify effects of differing flow schedules on juvenile production; and,
4. Make informed decisions when evaluating instream flow schedules for the Stanislaus River.

Methods

Juvenile fall-type Chinook salmon were collected and tagged between February 26 and May 19, 2007 in coordination with existing RST operations near Caswell (see Section 1). We added a third downstream trap in 2007 to increase available catch for tagging. Fish were marked with half-length and sequential decimal CWTs, and adipose fin clipped for subsequent identification. Multiple batches of unique tag codes were used for fry and parr during each 7-d period, or every 2,000 fish, whichever came first, and smolt migrants (> 60 mm) were uniquely marked with full-length sequential tags (Table 2.1). Quality control methods, described below, were used to ensure proper tag retention and to minimize migratory disruption. This approach was based on similar projects conducted on Butte Creek by CDFG since 1995, by CFS staff on the Mokelumne River in 2001 and 2002, and by the California Department of Water Resources (DWR) on the Feather River since 1998. We used equipment developed by Northwest Marine Technology (NMT), methods detailed in their product and protocol manuals (NMT 2003; Solomon 2005), and support from regional experts in the application of proper techniques (i.e., Big Eagle and Associates). We also developed and followed specific detailed protocols for CFS CWT operations (Gray et al. 2007b). Captured fish were transported from the trap live-box to holding tanks inside the CWT trailer for tagging.

Table 2.1. Batch codes, by tagging period, used in 2007.

Tagging Period	Batch Code
2/26/07 to 3/4/07	062401
3/5/07 to 3/11/07	062400
3/12/07 to 3/25/07	062402

Quality Assurance/Quality Control

A quality assurance/quality control program (QA/QC) ensured the tagging staff was properly trained, juvenile salmon were captured, tagged, and released in a manner consistent with NMT and CFS protocols, and that minimized stress and mortality. The QA/QC program also determined tag retention and mortality rates for marked fish.

Staff Training and Supervision

Staff training and initial supervision was provided by Big Eagle and Associates (Red Bluff, CA), and additional trainings by CFS were performed for field technicians. Jerry Big Eagle conducted staff trainings on January 29 at the Feather River tagging trailer and at Caswell on February 26; CFS conducted additional staff training on February 28, 2007. Additional technical support was provided by NMT technicians. Training sessions included details on proper fish handling, tag placement, tagging procedures, and equipment operation, maintenance and troubleshooting. All tagging staff members were aware of permit requirements and restrictions, and one person was always present with a current CDFG Scientific Collecting Permit.

Tagging Trailer and Operations

A tagging trailer (Figure 2.1) was set up immediately adjacent to the Caswell trap site location at the edge of Caswell Memorial State Park. The trailer provided a semi-permanent location to hold the equipment and materials needed for tagging operations (i.e., power source, tagging and QC equipment, water pump, etc).

Figure 2.1. Tagging trailer with generator in foreground (left) and (right) secured trailer.

All tagging procedures were conducted according to standard procedures recommended by Pacific Marine Fisheries Commission and NMT (PMFC 1983; Solomon 2005). A NMT Model Mark IV Automatic Tag Injector (MKIV) with a size-specific head mold was used to inject CWTs into the snout of each fish (NMT 2003) (Figure 2.2). The trailer was outfitted with three MKIV tagging stations.

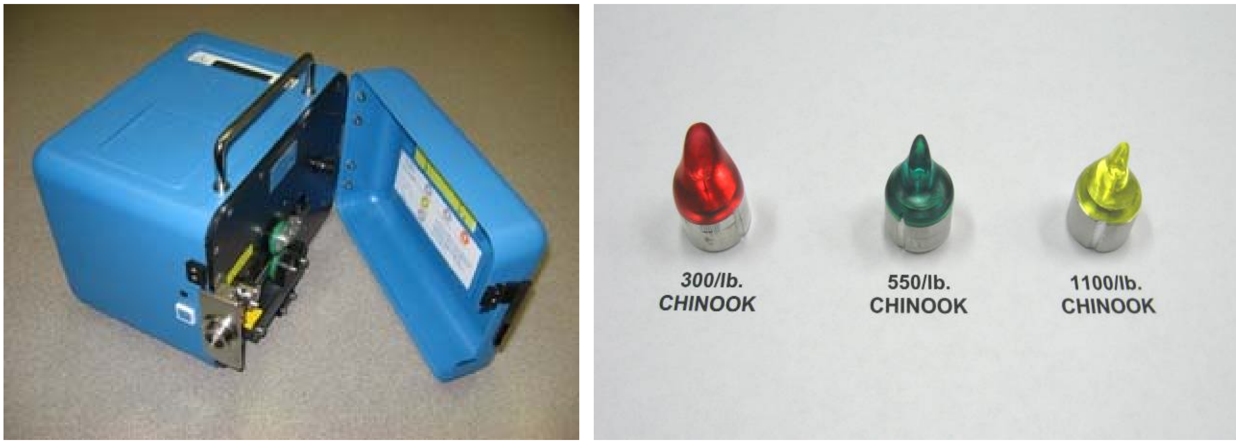

Figure 2.2. NMT Mark IV Automatic Tag Injector (left) and (right) head molds for fry, parr, and smolts (from right to left).

An etched needle was used instead of the larger non-etched needle. The etched needle has a smaller outside diameter (0.47 mm) from the beginning of the bevel, designed to make a smaller injection hole. This type of needle has been found to be very successful when used with head molds for Pacific salmon (Solomon 2005).

Size-specific head molds for fry (1,100/lb), parr (550/lb), and smolts (300/lb) allowed precise positioning of fish during tagging, and ensure proper tag implantation and internal placement (Figure 2.2). When tagging fry and parr, the snout easily fit into the mold without the eyes entering the interior portion of the mold. Likewise, a larger mold was used for tagging smolts. A suitable implantation site is critical to tag retention, fish health, and tag recovery. Tags were injected in the sinus cavity within muscle, adipose, and fibrous snout tissues (Figure 2.3, area C). The snout area, relatively large and far enough away from sensitive organs and tissue to prevent injury, is the most suitable implantation site for salmon (Solomon 2005).

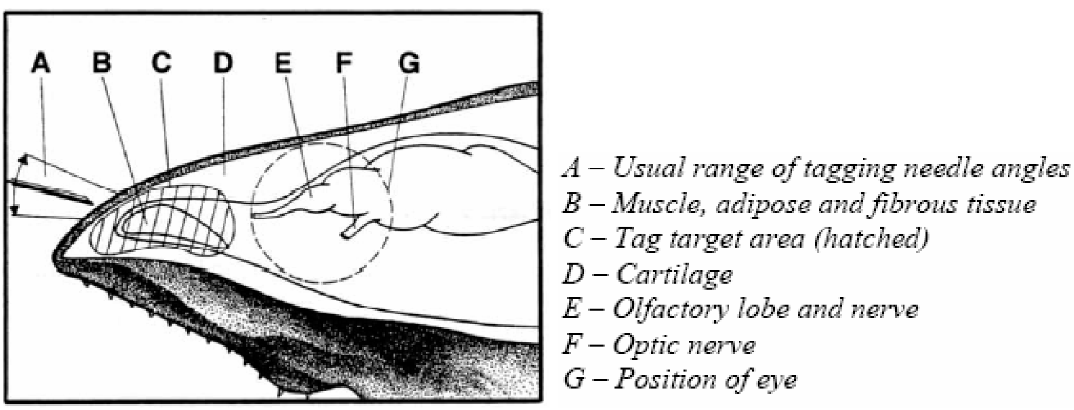

Figure 2.3. Typical tag placement for salmonids (Source: NMT 2003).

Fish were held upside down with head positioned in the proper-sized mold (Figure 2.4). Once held securely, the “tag” button was depressed and a needle quickly penetrated the snout and injected a tag to a pre-set depth before withdrawal. Tag presence was verified as the fish passed through the quality control device (i.e., T4 Detector).

Figure 2.4. MKIV fitted with a head mold for smolt tagging.

A half-length tag format was used for all fry and parr with unique batch codes for 2007 Caswell operations with specific codes for each tagging period. Each batch of tags was coded with a two-digit Agency code (to identify the agency or region of origin) and four single-digit data codes (Data 1, Data 2, Data 3 and Data 4) (Table 2.1). Batch codes were changed every 7 d for the first two weeks of tagging, and the final batch code was used for the remainder of the fry and parr tagging period since overall catches were low.

Similarly, smolt migrants were marked with full-length sequential tags. Smolts marked with sequential tags were grouped in daily batches. Due to the imprecise nature of how individual tags are cut, specific codes were not assigned to individual fish. Instead, prior to tagging the initial sequential tag was ejected from the MKIV and taped to the datasheet. Following completion of daily tagging operations the final tag was also ejected and taped to the datasheet. Initial and final tags were read with a NMT Magni-viewer (Figure 2.5) and recorded onto the datasheet to identify the range of tag codes used on that date. Daily batches provide for a more robust statistical interpretation of relationships between migration period, fish size, and environmental conditions when compared to several-day batches of half-tags. This technique of marking small groups of fish, with half-length batch coded tags or full-length sequential tags, enables recovered fish to be distinguished by their limited time period, or date, of emigration, respectively.

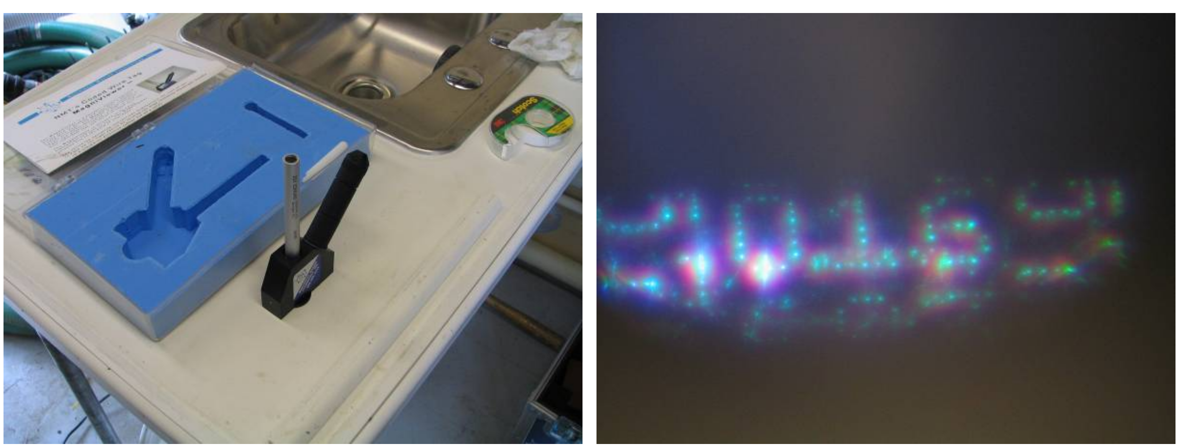

Figure 2.5. NMT Magni-viewer for reading CWTs (left) and code orientation on sequential CWT read through Magni-viewer (right).

Anesthetizing

All fish were anesthetized to avoid potential injury during handling and tagging procedures. A Tricaine-S solution was prepared in a separate, irrigated tank before being pumped to individual sinks for anesthetization during tagging procedures of small fish batches (< 25). A concentration of 25 mg/L was used as recommended by Big Eagle and Associates. Litmus strips were used to check pH, and baking soda (approximately 22.2 g) was added to buffer the acidity of the Tricaine-S solution to approximately 7 pH. The effectiveness of Tricaine-S varies with temperature and fish density; therefore, adjustments were made accordingly during actual periods of tagging. Water temperatures were maintained between 10ºC and 19ºC, and frozen water bottles were added to the tank when temperatures approached the maximum acceptable level.

When tagging operations were ready to proceed, fish were netted from holding tanks and placed in the Tricaine-S sink. No more than 25 fish were placed in a sink at a time. As soon as an individual fish lost equilibrium (2-5 min), it was gently removed by hand (while remaining submerged) and closely examined for external tags, fin clips, descaling, injuries, or signs of disease. If the fish was deemed unsuitable for tagging, it was placed in a designated reject bucket to recover. Prior to tagging, a suitable fish was weighed (g), FL measured (mm), and its adipose fin was removed with surgical scissors to indicate the presence of a CWT.

Tagging Quality Assurance/Quality Control

Initially, to ensure correct tag placement, one to two fish were sacrificed per day and an experienced tagging operator examined tag placement. A small scalpel was used to cut parallel to the needle hole back to the median of the eyes. The scalpel blade was then twisted slightly in order to reveal the inner section of the snout. Properly placed tags appeared in the center of the triangular shaped connective tissue within the snout. We found this procedure unnecessary for very small fry (35-45 mm) and discontinued the process as tags could be viewed by opening the mouth and observing the tag ventrally through the snout. For small groups, all tag placements were verified; for larger groups approximately 10% of fish were examined as tagging occurred. If problems with tag placement existed, the tag depth was adjusted with fine movements (i.e., in or out) of the head mold. Head molds were marked with permanent ink or pencil to coarsely indicate correct positioning. Fine adjustments were made to position the head mold during tagging. To minimize sacrificing wild Chinook salmon, when available, we used juveniles that died as a result of trapping or handling for initial estimates of correct tag placement.

Following tagging, fish were immediately released into a sink and drain system which exited the trailer into the portable quality control device (Model T4 Detector manufactured by NMT) to verify CWT presence in tagged fish (Figure 2.6, left). When a CWT was detected, a gate opened to divert tagged fish into an outside holding tank. Untagged fish were diverted to a separate holding area within the larger holding tank (Figure 2.6, right).

Figure 2.6. NMT T4 Detector (left) holding tank division to separate marked and unmarked fish arriving from T4 Detector (right).

Holding

Between March 3 and March 19, when catch numbers were low (i.e., < 20 fish/d), fish were held overnight to increase tagging group size to optimize the efficiency of trailer operation. Fish were held in protected net pens in the river, and were tagged with the next day's catch. We held fish to increase tagging group size to optimize the efficiency of trailer operation. Prior to tagging, fish were transported from the RST live-box and net pens into a pre-tagging holding tank located in the tagging trailer. The holding tank was continuously supplied with fresh river water and bubblers with aeration stones to maintain high oxygen saturation. We periodically monitored water temperature which was maintained between 10 ºC and 19ºC. External post-tagging recovery tanks were shaded and monitored in the same manner as the pre-tagging holding tanks.

Monitoring Tag Retention and Mortality Rates

When the 3% sub-sample resulted in less than 50 fish, we held entire groups of tagged fish to monitor mortality rates and determine tag retention rates. We held fish in net pens (in-river) for 24 hours. We recorded number of mortalities, determined presence of tags with the T4 Detector and recorded number of tagged and untagged fish. On rare occasions fish escaped from holding pens. We recorded escaped fish as alive and omitted them from tag retention estimates as the information was unavailable.

Release

In cases where we released fish immediately following tagging, we held fish until fully recovered from the effects of anesthesia (at least one hour) and then returned them to the river immediately downstream of the traps. Every effort was made to release fish at night, or in small groups near cover, to minimize post-release predation. Mortalities were documented in the release report as were the number of fish that shed tags.

Tag Code Reporting

Once tag groups were completely processed, a CWT release report was sent to Robert Kano (CDFG - CWT Program Coordinator). Regional coordination of various tagging programs is provided by the Regional Mark Processing Center, which is operated by the Pacific States Marine Fisheries Commission. This center also maintains a centralized database for coast-wide CWT releases and recoveries, as well as for associated catch and sample data. CWT data are provided to users via interactive on-line data retrieval. For further information on recovery processes, please review information given by the Regional Mark Processing Center (www.rmpc.org).

Routine Maintenance

Tagging equipment was cleaned at the end of each session. All internal equipment components were cleaned with isopropanol (70% solution). Head molds, interior surfaces of the T4 Detector, and countertops were wiped and disinfected with a dilute bleach solution.

Tag Recovery

Data for both juvenile and adult CWT recoveries could potentially be obtained from:

- CDFG Central Valley spawning ground carcass surveys
- Interagency Ecological Program (IEP) trawl and seine data
- Pumping salvage
- CDFG Mossdale trawls
- Pacific States Marine Fisheries Commissions' RMIS database
- Central Valley salmon and steelhead in-river harvest and monitoring program (starting 2007)

California CWT monitoring programs are designed to sample at least 20% of Chinook salmon landed in ocean troll and recreational fisheries. Sampling California inland waterways occurs through a systematic creel survey on the Klamath-Trinity Rivers and sporadic sampling of fisheries in the Sacramento and San Joaquin basin. In-river CWT recoveries are also obtained from hatchery returns and spawning ground surveys. We estimate the majority of CWT recoveries in the Stanislaus River will occur during annual spawning ground surveys conducted by CDFG.

Results

Tagging

Between February 26 and May 18, 987 juvenile Chinook salmon were tagged at the Caswell RST site (34% of season's total fish captured) (Figure 2.7). In all, 839 tagged fish (656 half-tags and 183 full-tags) were released during this period (Table 2.2). Peak tagging occurred between February 26 and March 4 (520 CWT fish released); a total of 348 (91%) tagged fish were released on March 1 alone.

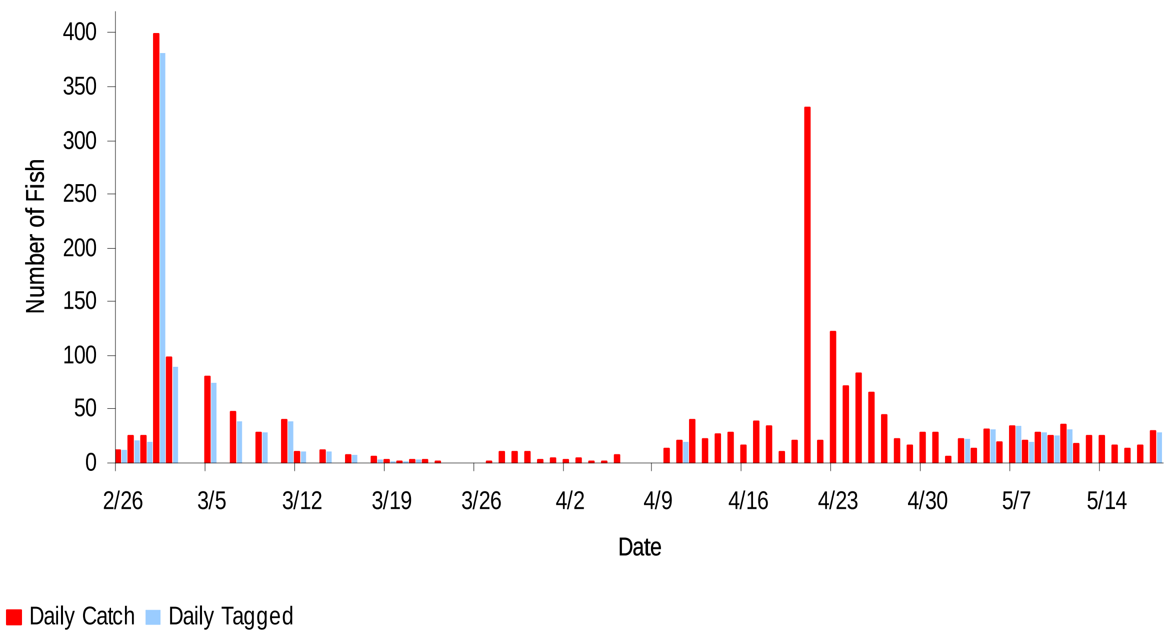

Figure 2.7. Daily catch versus total CWT juvenile Chinook salmon, 2007.

Table 2.2. Number of fish released for each batch code (fry and parr), and tag code (smolts) with range of sequential codes used, by tagging period.

Tagging Period	Batch/Tag Code	Total No. Released	Avg. Size (mm FL)
2/26/07 to 3/4/07	062401	520	35.0 ±0.2
3/5/07 to 3/11/07	062400	108	34.9 ± 0.5
3/12/07 to 3/25/07	062402	28	38.6 ± 2.1
3/21/07 to 5/18/07	06-19-63 (00577 through 01161)	183 - 192	Average FL for CWT date

Mortality

Trap mortality rates on tagging days were 2.9% (n = 31) of the catch while pre-tagging mortalities, mostly from fish held overnight, accounted for 7.4% (n = 12) of all fish held in this manner (n = 163) (Table 2.3; Figure 2.8). Twenty-seven other fish were released alive prior to tagging. Mortalities directly related to tagging accounted for 2.9% (n = 29) of all tagged fish (n = 987) (Figure 2.9). Post-tag mortalities, resulting from holding fish until evening or overnight prior to release, accounted for 5.6% (n = 54) of all fish held for this purpose.

Table 2.3. Summary of total catch, tagging numbers, and mortality rates during periods of CWT operations at Caswell, 2007.

Total Catch	Trap Mortalities	Pre-tagging Mortalities	Number of Fish Tagged	Tagging Mortalities	QC Mortalities	Number of Fish Released w/ Tags
1059	2.9% (n = 31)	7.4% (n = 12)	987	2.9% (n = 29)	5.6% (n = 54)	839

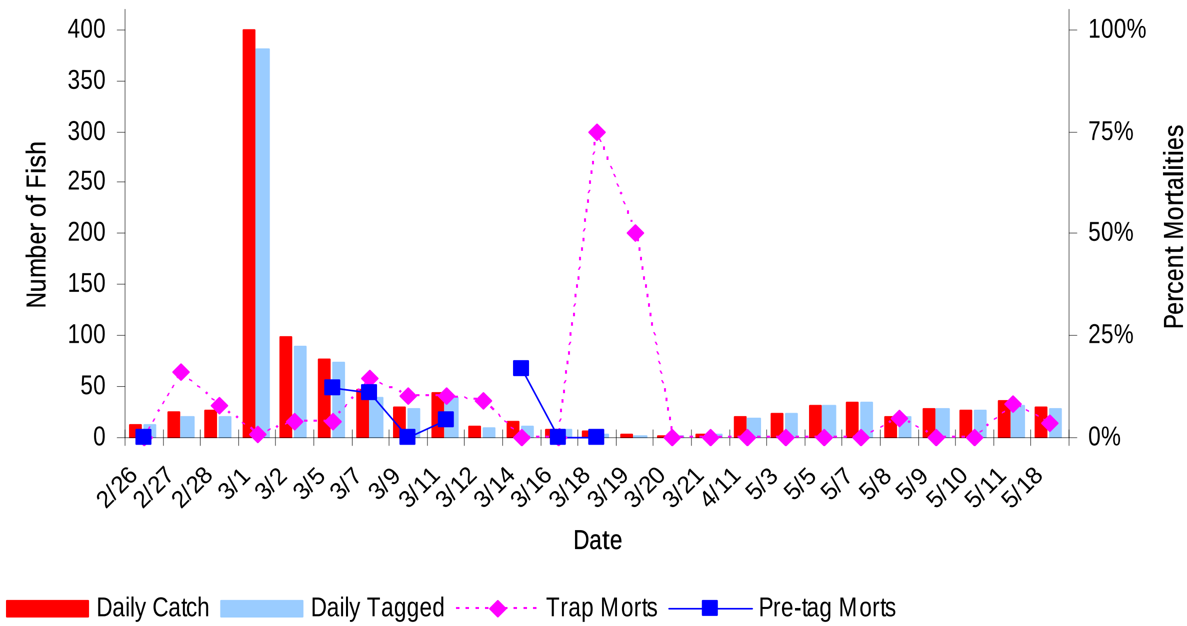

Figure 2.8. Trap mortalities and pre-tagging mortalities for days of CWT tagging.

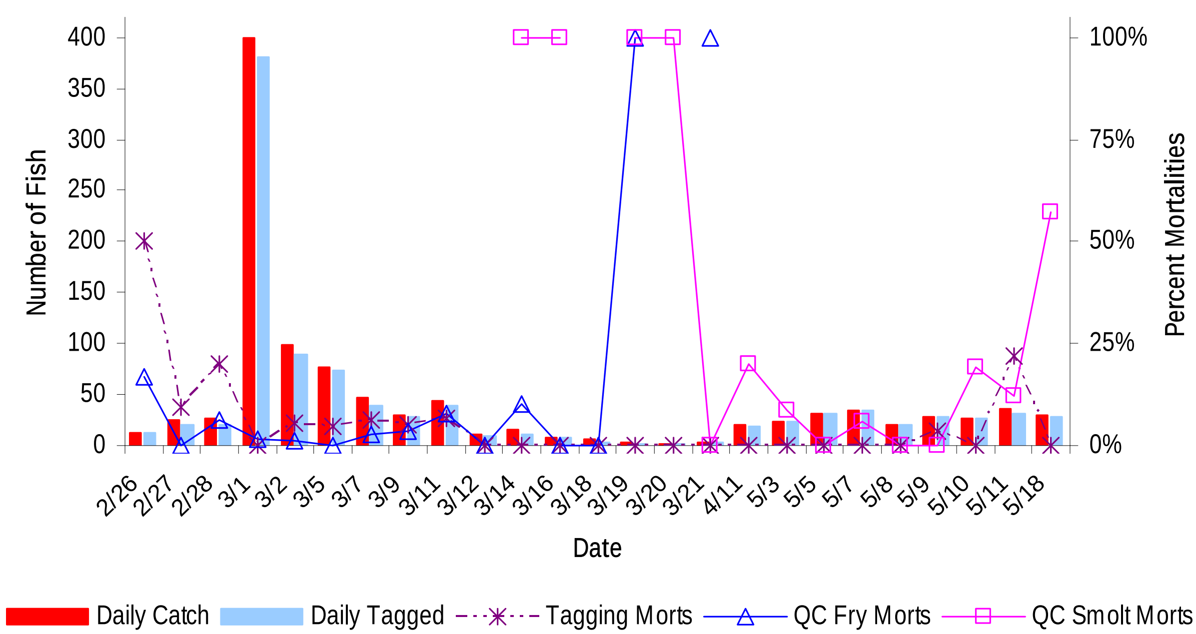

Figure 2.9. Tagging mortalities and QC mortalities for fry versus smolts for days of CWT tagging.

Tag Retention

Tag retention rates were 93% (n = 876) for all fish subjected to testing (Table 2.4; Figure 2.10). Half-length tag retention was 93.2% (n = 659) while full-length tag retention was 91.2% (n = 217). The lowest retention rates for fish receiving half-tags (47%; n = 9) occurred on February 27. Low rates for full-length tag retention (70%, 70% and 75%; n = 11, 19, and 12, respectively) occurred on April 11, May 9, and May 18, respectively.

Table 2.4. Total tag retention rates for QC'd fish.

Half-length Tags	Full-length Tags	Overall
93.2% (n = 659)	91.2% (n = 217)	93.0% (n = 876)

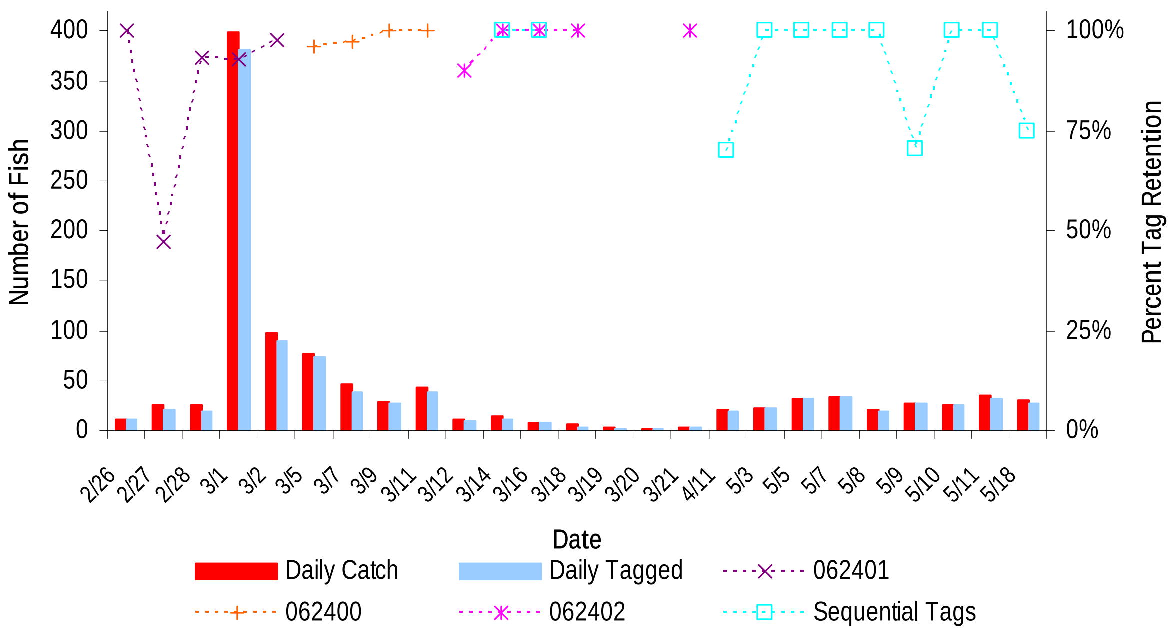

Figure 2.10. Total catch, total tagged, and tag retention rates, by group of tagged fish, for days of CWT tagging.

Tag Recoveries

Three juvenile Chinook salmon CWT tagged at the Caswell RST were recovered in spring 2007 (Table 2.5; Figure 2.11). The first recovery of a 70 mm FL Chinook salmon occurred on April 1 at the CVP pumps run by DWR. This fish was half-tagged in the last batch (062402) between March 12 and March 25, and released in a group of 28 tagged fish with an average FL of 38.6 ± 2.1 mm for fish captured in the RST during this period. The second recovery occurred on April 4 in the CDFG Mossdale trawl. This fish was 70 mm when recovered, was full- tagged on March 21, released in a group of 1 fish, and was 65 mm when tagged. The recovered tag was unreadable due to improper cutting and an error in MKIV settings, which was immediately corrected (J. Guignard, CDFG, reported this recovery immediately after catch). The third recovery occurred on April 27 in the CDFG Mossdale trawl. This fish was 88 mm when recovered and was half- tagged in the first batch (062401) between February 26 and March 4. The fish was released in a batch of 520 fish with an average FL of 35.0 ± 0.2 mm for fish captured in the RST during this period.

Table 2.5. Juvenile CWT recovery information, 2007

Recovery Date	Tagging Date	Code	Recovery Location	Avg. Size at Tagging (mm FL)	Size at Recovery (mm FL)
4/1/07	3/12/07 to 3/25/07	062402	CVP	38.6 ± 2.1	70
4/4/07	3/21/07	Unknown	Mossdale trawl	65	70
4/27/07	2/26/07 to 3/4/07	062401	Mossdale trawl	35.0 ±0.2	88

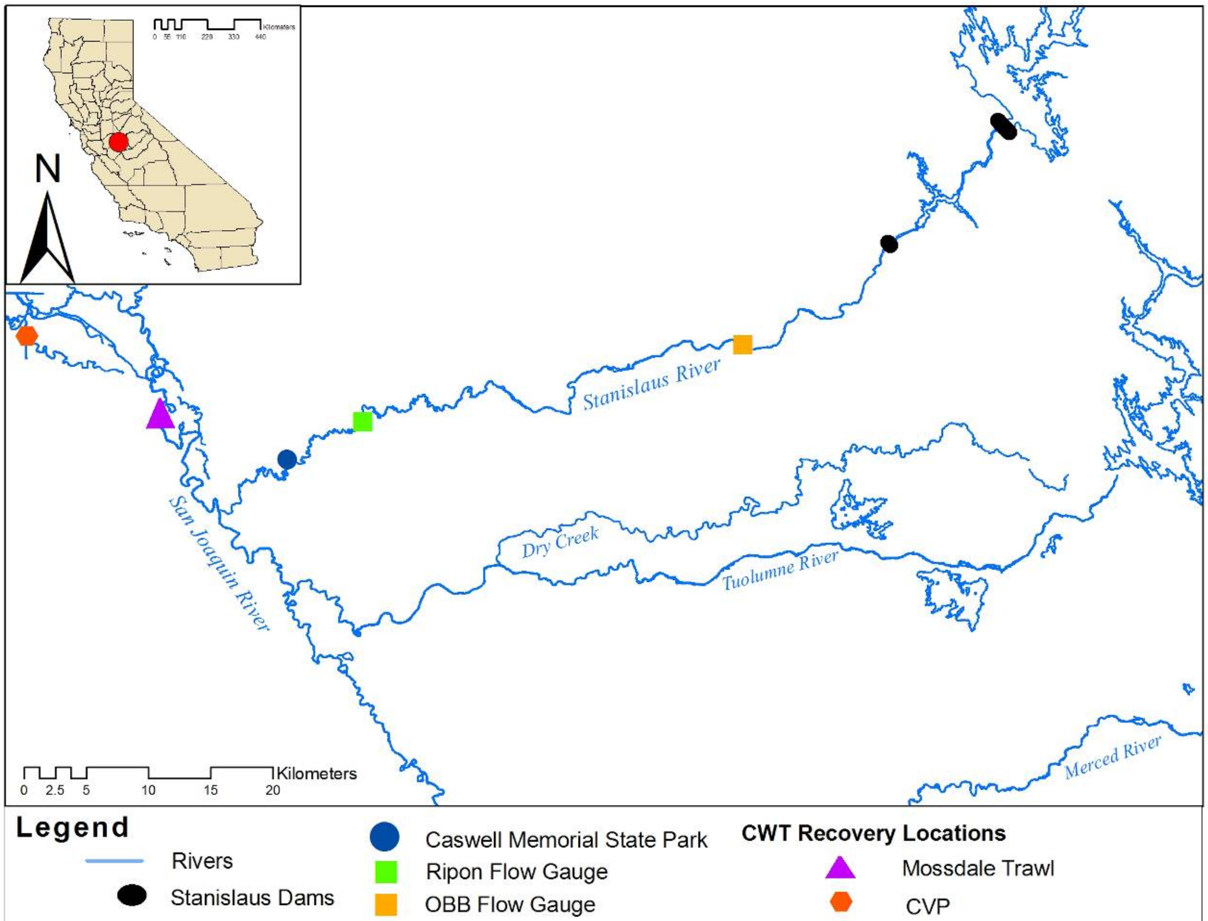

Figure 2.11. Location of recaptures at the CVP pump station in the south delta and the Mossdale trawl site in the lower San Joaquin River, California, 2007.

Discussion

During the 2007 pilot year of the CWT project, we established a CWT trailer facility at Caswell, consulted with CWT experts and conducted staff trainings, developed operational protocols, operated the CWT trailer and identified fish health concerns on the Stanislaus River. Our total number of fish captured this season (n = 2,909) was far below the anticipated catch and resulted in only 839 fish released with tags (~29% of captured fish). Based on previous years' data, annual sample sizes for juvenile Chinook salmon were anticipated to be approximately 25,000 fry and parr (< 60 mm) and 5,000 smolts (> 60 mm). Maximum annual tag-group catches were not expected to exceed 60,000 fry and parr, and 10,000 smolts. The total catch for Caswell was an order of magnitude smaller than expected, and was further compromised by problems related to fish health. The lower catch numbers and fish health problems resulted in limited tagging throughout the smolt out-migration period.

Trapping and handling-related tagging mortality rates were generally low (2.9% overall), although initially, tagging related fry mortality was high (max = 50% or six individual fry on the first day of tagging due to tag placement training activities). During the fry tagging period (February 26 to March 4), trapping mortality was 2.2%, tagging mortality was 3.1% (n = 18), and quality control (i.e., fish checked for tag retention and held to recover) holding mortality was 1.6%. From March 5 to March 21, trap mortalities increased to 6.6% (n = 12), tag mortality rates decreased to 1.9% (n = 3), and quality control holding mortality rates increased to 5.8% (n = 9) concurrently with decreasing catch numbers. Field observations of poor fish health were first recorded during this period (see Fish Health discussion below).

Subsequently, during the early stages of Chinook salmon smolt out-migration (after March 14) when only a few fish (n = 5) were captured and tagged, quality control holding mortalities were extremely high (80%, n = 4). Cramer Fish Sciences staff conducted conference calls with USFWS, BOR and CDFG to determine if operations should continue considering the decreased catch numbers, increased mortality rates, and observed poor fish health. Cramer Fish Sciences was directed to continue operations with caution (when fish were in good condition) and conduct a controlled experiment to test survival related to tagging and quality control procedures. This experiment was conducted by CFS staff at the Feather River CWT trailer on March 26. We tagged 50 hatchery fish using our CWT equipment, taggers, and field procedures. Tagged fish (treatment group) were marked with fin clips and held together with 50 untagged fish (control group) for 48 hours with a resulting survival of 100% for both tagging and holding. These results supported NMT information that found tagging related mortalities less than 1% and minimal adverse affects on post-tagging survival (NMT Biological Division, personal communication).

On April 11, we resumed tagging operations when catch increased, meeting a predetermined minimum (> 20). Trap and tagging mortalities were both 0% while quality control holding mortalities were 25% (n = 4). Further consultation with project partners resulted in the suspension of tagging operations, due to concerns regarding high observed mortality. It was determined that tagging should not continue until several consecutive days of general good fish health were observed. Although 1,044 Chinook salmon were captured between April 12 and 30, field reports of fish condition and health were generally poor; therefore, tagging did not commence. With permission from CDFG, we also agreed to provide the USFWS CA-NV Fish Health Center with specimens needed to assess fish health and condition. Four fish were sacrificed on April 23, fixed, and delivered to the laboratory for histological analysis. The pathology report detailed results of histological assays conducted and determined gill damage from external bacterial columnaris (*Flavobacterium columnare*) infection as the primary health problem (Appendix 2).

In May, following increased flows and several days of observed improvement in juvenile Chinook salmon condition, tagging operations were reinitiated. We tagged smolts (n = 223) for eight days between May 3 and 18. During this period, trap mortalities were 2.2% (n = 5), tag mortalities were 3.6% (n = 8), and quality control mortalities were 13% (n = 28). On May 11, three of these trap and seven smolt tagging mortalities occurred; corresponding quality control mortalities were 12% (n = 3) for these smolts. On May 18, quality control mortalities (57%; n = 16) were substantial for the final tag group (n = 28) while only one (3.3%) trap mortality occurred. We ceased tagging operations following the May 18 tag date.

To evaluate the context of our mortality rates, we investigated past efficiency marking/holding mortality and found it to range from 2.1% to 6.6%. Capture and pre-tagging handling mortality rates on the Kenai and Killey Rivers, Alaska, were 6.5% and 1.7% for all CWT Chinook salmon smolts greater than 65 mm (King and Breakfield 2002); similarly, post-handling 24-h mortality rates were less than 1% for all tagged juvenile Chinook salmon (> 55 mm) on the Deschutes River, Oregon (Brun 2003). King and Breakfield (2002) stated their mortality rates were inflated due to initial operational procedures related to trap placement and trap check frequency; the authors reduced mortality rates by reducing the time between capture and marking, and minimizing the number of times fish were handled.

Fry CWT retention rates during the first tagging period (February 26 - March 4) were 92.3% (n = 520) while combined retention rates for the next two tagging periods between March 5 and 21 were 96.5% (n = 139). The overall retention rate of 91.2% (n = 217) for smolts was adversely affected by three days of low retention when all 21 tags were lost. Solomon (2005) states CWT retention rates have been shown to exceed 95% for parr following proper tag placement. In the Kenai and Killey Rivers, short-term tag retention for smolts (> 65 mm) receiving CWTs was 96.5% and 99.5%, respectively (King and Breakfield 2002). Likewise, Brun (2003) recorded tag retention rates of 99.5% for all fish (> 55 mm) tagged, and reported no noticeable difference between handling mortality and tag retention rates for fish between 55 and 69 mm versus fish greater than 70 mm. The importance of proper tag depth and placement to successful long-term CWT retention is critical (Blankenship 1990; NMT 2003; Magnus et al. 2006). Cramer Fish Sciences staff may have been tentative in determining tag placement, opting for shallower placement in an attempt to compensate for problems in previous weeks with mortalities and fish condition. Such operational issues were localized to two identifiable events, and we expect the majority of released fish experienced retention rates similar to those observed in other studies (i.e., King and Breakfield 2002; Brun 2003; Solomon 2005).

Although 2007 was the pilot year for the CWT project, we already obtained valuable data from several tag recoveries. We recovered three CWTs from fish tagged at Caswell. The first fish recovered by the pumps was part of a small group (n = 28) and provides us with a piece of information about the possible level of entrainment encountered. The second fish recovered was a smolt caught by CDFG at Mossdale which reflected an expected migration pattern and also alerted us to problems with MKIV settings, which we immediately corrected. The third fish recovered was marked early in the season and again collected by CDFG at Mossdale; and suggests this fish reared for several weeks in the lower Stanislaus and San Joaquin River. We were pleased with these recoveries and the additional acquisition of information on our tagged fish, especially during this limited-extent pilot season, and we expect better results in coming years.

Fish Health

Columnaris infections are known to become more pervasive with higher water temperatures (Holt et al. 1975; Boles et al. 1988). Stressors (i.e., high water temperature, low DO, crowding, handling and mechanical injury) are evidently a key factor contributing to infection rates (Schachte 1983), and many fish species become susceptible to columnaris when water temperatures approach the upper limits of their preferred temperature ranges (Durborow et al. 1998). Increasing water temperatures (typically > 12.2°C) favor bacteria causing columnaris and other infections, including furunculosis (infection by *Aeromonas salmonicida*) and ichthyophthiriosis (or ich; infection by *Ichthyophthirius multifilis*) (Holt et al. 1975; Boles et al. 1988). Columnaris epidemics frequently occur in natural fish populations, since no species are resistant to the disease, and can result in substantial mortality, with highly virulent forms attacking gill tissues (Schachte 1983). Columnaris bacteria affecting the gills grow in spreading patches and eventually cover gill filaments resulting in cell death (Durborow et al. 1998). Individuals infected with columnaris function as sources of infection and readily spread the disease to other fish (Schachte 1983) intermittently infecting entire groups of fish throughout the season (e.g., in the RST live-box). Columnaris infections have not been thoroughly documented for the Stanislaus River and occurred with relatively low water temperatures (S. Foott, USFWS CA-NV Fish Health Center, personal communication); therefore, continued work with the USFWS CA-NV Fish Health Center in the 2008 field season will attempt to determine the prevalence of infection and possible related factors on the Stanislaus River.

Recommended Future Work (Sections 1 and 2)

Our recommendations for future work on the Stanislaus River include continued RST monitoring and CWT marking at Caswell, evaluation of otolith microchemistry techniques to evaluate life stage contribution, coordinating with the USFWS CA-NV Fish Health Center to evaluate the prevalence of disease problems, evaluation of the addition of robust water quality sampling, and more detailed data on fish foraging success and condition. In addition, we recommend streamlining field protocols to enhance efficiency in sampling, and modifying the existing CWT trailer and equipment configurations to improve operational procedures.

Specifically, we suggest the following changes and adjustments to RST operations:

1. Install TidBit™ temperature loggers (Onset Technology, Inc.) at the trap and in the live-box to continuously monitor water temperature conditions experienced by passing and trapped fish;
2. Perform pre- and post-sampling cross channel elevation transects to determine river morphology changes due to trapping and/or temporary structure; and,
3. Adjust field data collection protocols to improve measures of trap effort and include trap effort in passage estimate analysis.

We plan to work with CAMP and AFRP to revise and standardize protocols for all RST out-migration monitoring projects throughout the San Joaquin basin. These revisions may include, but are not limited to: (1) the time of day trap processing occurs; (2) days of operation for sub-sampling; and, (3) efficiency testing procedures. Standardizing monitoring methods may facilitate the development of standardized analysis protocols and reporting guidelines. These efforts will greatly enhance reporting efforts and communication between scientists and managers, may improve efficiency in salmon fisheries management and support, and promote informed approaches to address critical problems associated with continuing declines of Chinook salmon and *O. mykiss* runs in the entire San Joaquin basin.

Acknowledgements

Funding for this study was provided by USFWS AFRP and BOR. We are very thankful for the technical support and assistance of J. D. Wikert and other USFWS staff. We would also like to thank CFS field staff for their hard work in acquiring these data: Will Clayton, Joe Deppen, Garrett Grohl, Mike Justice, Mike Kersten, Shannon Lee, John Montgomery, Tyson Mutoza, and Jeremy Pombo.

In addition, we acknowledge the following organizations and individuals for their contribution to this project:

- Jason Guignard and Tim Heyne of CDFG (La Grange Field Office) for their help with planning, permitting, and coordinating our field operations;
- Stanislaus River Fish Group for support and advice on project objectives and methods;
- Ron Morrow and the staff at South San Joaquin Irrigation District for their help with RST installation and removal;
- Joanne Karlton of State Parks for granting access through their Caswell Memorial State Park;
- Oakdale Wastewater Treatment Plant staff for storing our equipment; and,
- Brocchini Farms and their staff for providing us continued access to the river and use of their property for placement of the coded wire tagging trailer.

References

Anderson, J. T., C. B. Watry, and A. Gray. 2007. Adult Chinook salmon counts using a portable resistance board weir in the Stanislaus River, California, 2007. Annual Report of Cramer Fish Sciences to U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program, Grant No. 813326G004, Stockton, California.

Augerot, X., D. N. Foley, C. Steinback, A. Fuller, N. Fobes, and K. Spencer. 2005. Atlas of Pacific salmon: the first map-based status assessment of salmon in the north Pacific. University of California Press, Berkeley and Los Angeles.

Baker, P. F., T. P. Speed, and F. K. Ligon. 1995. Estimating the influence of temperature on the survival of Chinook salmon smolts (*Oncorhynchus tshawytscha*) migrating through the Sacramento – San Joaquin River Delta of California. Canadian Journal of Fisheries and Aquatic Sciences 52(4):855-863.

Blankenship, H. L. 1990. Effects of time and fish size on coded wire tag loss from Chinook and coho salmon. American Fisheries Society Symposium 7:237-243.

Boles, G. L., S. M. Turek, C. D. Maxwell, and D. M. McGill. 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River - a literature review. State of California Department of Water Resources, Northern District.

Brun, C. 2003. Final Report: Juvenile fall Chinook salmon coded wire tagging feasibility study in the Deschutes River, Oregon. Confederated Tribes of the Warm Springs Reservation, Oregon, Cooperative Agreements: COOP-02-075 and COOP-02-076.

Cezilly, F. 1992. Turbidity as an ecological solution to reduce the impact of fish-eating colonial waterbirds on fish farms. Colonial Waterbirds 15:249-252.

Coutant, C. C. 1973. Effect of thermal shock on vulnerability of juvenile salmonids to predation. Journal of the Fisheries Research Board of Canada 30:965-973.

Demko, D. B. and S. P. Cramer. 1997. Out-migrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park, 1996. Report of S. P. Cramer & Associates, Inc. to U.S. Fish and Wildlife Service, Stockton, California.

Demko,D. B. and S. P. Cramer. 1998. Out-migrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park, 1997. Report of S. P. Cramer & Associates, Inc. to U.S. Fish and Wildlife Service, Stockton, California.

Demko, D., B. C. Gemperle, S. P. Cramer, and A. Phillips. 1999a. Out-migrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park, 1998. Report of S. P. Cramer & Associates, Inc. to U.S. Fish and Wildlife Service, Stockton, California.

Demko, D., B. C. Gemperle, S. P. Cramer, and A. Phillips. 1999b. Out-migrant trapping of juvenile salmonids in the lower Stanislaus River Caswell State Park, 1999. Report of S. P. Cramer & Associates, Inc. to U.S. Fish and Wildlife Service, Stockton, California.

Dobson, A.J. 2002. An Introduction to Generalized Linear Models (second edition). Chapman and Hall, London.

Durborow, R. M., R. L. Thune, J. P. Hawke, and A. C. Camus. 1998. Columnaris disease: a bacterial infection caused by Flavobacterium columnare. Southern Regional Aquaculture Center, Publication No. 479. Stoneville, Mississippi. Available: http://govdocs.aquake.org/cgi/reprint/2003/727/7270100.pdf. (July 2007).

Fleming, C. 1997. 1995 Stanislaus River Emigration Survey. U. S. Fish and Wildlife Service, Stockton, California.

Foss, S. 2005. Salvage of hatchery-released juvenile steelhead at the State Water Project and Central Valley Project fish facilities. Interagency Ecological Program for the San Francisco Estuary Newsletter 18(2):43-46. Available: www.iep.ca.gov/report/newsletter/2005_newsletters/IEPNews_spring2005final.pdf. (Spring 2005).

Giannico, G. R., and M. C. Healey. 1998. Effects of flow and food on winter movements of juvenile coho salmon. Transactions of the American Fisheries Society 127:645-651.

Gradall, K. S. and W. A. Swenson. 1982. Responses of brook trout and creek chubs to turbidity. Transactions of the American Fisheries Society 111:391-395.

Gray, A., R. Cuthbert and B. Cavallo. 2007a. Rotary screw trapping protocol: A detailed protocol for rotary screw trapping operations for the Stanislaus and Merced rivers. Cramer Fish Sciences, 32 pp.

Gray, A., R. Cuthbert and B. Cavallo. 2007b. Coded wire tagging operations protocol for Chinook salmon in the Stanislaus River. Cramer Fish Sciences, 18 pp.

Gregory, R. S. 1993. Effect of turbidity on the predator avoidance behaviour of juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 50:241-246.

Gregory, R. S. and C. D. Levings. 1998. Turbidity reduces predation on migrating juvenile pacific salmon. Transactions of the American Fisheries Society 127:275-285.

Holt, R. A., J. E. Sanders, J. L. Zinn, J. L. Fryer, and K. S. Pilcher. 1975. Relation of water temperature to Flexibacter columnaris infection in steelhead trout (*Salmo gairdneri*), coho (*Oncorhynchus kisutch*), and Chinook (*O. tshawytscha*) salmon. Journal of Fisheries Research Board of Canada, 32:1553-1559.

Holtby, L. B., T. E. McMahon, and J. C. Scrivener. 1989. Stream temperatures and inter-annual variability in the emigration timing of coho salmon (*Oncorhynchus kisutch*) smolts and fry and chum salmon (*O. keta*) fry from Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46:1396-1405.

Johnson, P. N. and M. D. Rayton. 2007. Enumeration of juvenile salmonids in the Okanogan Basin using rotary screw traps. Report of LGL Limited Environmental Research Associates and Colville Tribes Fish and Wildlife to U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon.

King, B. E. and J. A. Breakfield. 2002. Chinook and coho salmon coded wire tagging studies in the Kenai River and Deep Creek, Alaska, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 02-03, Soldotna.

Kjelson, M. A., P. F. Raquel, and F. W. Fisher. 1981. Influences of freshwater inflow on Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin estuary. Pages 88-102 in R. D. Cross and D. L. Williams, editors. Proceedings of the national symposium on freshwater inflow to estuaries. U.S. Fish and Wildlife Service, FWS/OBS-81/04(2).

Kondolf, G. M., A. Falzone, and K. S. Schneider. 2001. Reconnaissance-level assessment of channel change and spawning habitat on the Stanislaus River below Goodwin Dam. Report of G. Mathias Kondolf to U.S. Fish and Wildlife Service, Sacramento, California.

Magnus, D. L., D. Brandenberger, K. F. Crabtree, K. A. Pahlke, and S. A. McPherson. 2006. Juvenile salmon capture and coded wire tagging manual. Alaska Department of Fish and Game, Special Publication No. 06-31, Anchorage, Alaska.

May, J. T. and L. R. Brown. 2002. Fish communities in the Sacramento River basin: implications for conservation of native fishes in the Central Valley, California. Environmental Biology of Fishes 63: 373-388.

McCullagh, P., and Nelder, J.A. 1989. Generalized Linear Models (second edition), Chapman and Hall, London.

Moyle, P. B. 2002. Inland fishes of California. Revised and expanded. University of California Press, Berkeley and Los Angeles.

Nehlsen, W., J. E. Williams, and J. A. Lichatowich. 1991. Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Northwest Marine Technologies (NMT). 2003. Mark IV instruction manual: automated coded wire tag injector. Northwest Marine Technologies, Inc., Shaw Island, WA. Available: http://www.nmt.us/products/cwt/mkiv/mkiv_manual.pdf. (July 2007).

Pyper, B. J. and M. Simpson. In prep. Factors influencing catch rates of juvenile Chinook salmon by rotary screw traps in the Stanislaus River, California. Cramer Fish Sciences, Gresham Oregon.

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. University of Washington Press, Seattle, Washington.

Reimers, P. E. 1973. The length of residence of juvenile fall Chinook salmon in Sixes River, Oregon. Fish Commission of Oregon, Research Reports of the Fish Commission of Oregon 4(2), Portland, Oregon.

Roper, B. B. and D. L. Scarnecchia. 1998. Emigration of age-0 Chinook salmon (*Oncorhynchus tshawytscha*) smolts from the upper South Umpqua River basin, Oregon, USA. Canadian Journal of Fisheries and Aquatic Sciences 56:939-946.

Schachte, J. H. 1983. Columnaris Disease. Pages 199-203 in F. P. Meyer, J. W. Warren, and T. G. Carey, editors. A guide to integrated fish health management in the Great Lakes basin. Great Lakes Fishery Commission, Special Publication No. 83-2, Ann Arbor, Michigan. Available: http://www.glfc.org/pubs/SpecialPubs/sp83_2/pdf/chap23.pdf. (July 2007).

Schneider, K. S., G. M. Kondolf, and A. Falzone. 2003. Channel-floodplain disconnection on the Stanislaus River: a hydrologic and geomorphic perspective. Pages 163-168 in P. M. Faber, editor. California riparian systems: Processes and floodplain management, ecology, and restoration. Riparian habitat and floodplains conference proceedings, Riparian habitat joint venture, Sacramento, California.

Seesholtz, A., B. J. Cavallo, J. Kindopp, R. Kurth. 2004. Juvenile fishes of the lower Feather River: distribution, emigration patterns, and associations with environmental variables. American Fisheries Society Symposium 39:141-166.

Solomon, D. J. 2005. Coded wire tag project manual - guidelines on the use of coded wire tags and associated equipment. Northwest Marine Technologies, Inc., Shaw Island, Washington. Available: http://www.nmt.us/support/appnotes/apc15.pdf. (July 2007).

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58(2):325-333.

Sparkman, M. 2001. Redwood Creek rotary screw trap downstream migration study Redwood Valley, Humboldt County, California April 4 – August 5, 2000. Report of Michael Sparkman to Redwood Creek Landowners Association, Humboldt County, California.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz and K. V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14:837-851.

U.S. Fish and Wildlife Service (USFWS). 2003. Abundance and survival of juvenile Chinook salmon in the Sacramento-San Joaquin estuary. 1999 Annual Progress Report, Sacramento-San Joaquin Estuary Fishery Resource Office, U.S. Fish and Wildlife Service, Stockton, California.

U.S. National Oceanic Atmospheric Administration. 2004. Endangered and threatened species, establishment of species of concern list, addition of species to species of concern list, description of factors for identifying species of concern, and revision of candidate species list under the Endangered Species Act. Federal Register 69(73):19975-19979.

Venables, W.N. and Ripley, B.D. 1999. Modern Applied Statistics with S-PLUS. Springer-Verlag, New York.

Williams, J. G. 2006. Central Valley salmon: a perspective on Chinook and steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science 4(3): Article 2. Available: http://repositories.cdlib.org/jmie/sfews/vol4/iss3/art2/. (July 2007).

Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Pages 71–176 in R. L. Brown, editor. Contributions to the Biology of Central Valley Salmonids, Fish Bulletin 179. California Department of Fish and Game, Sacramento.

Zimmerman, M. P. 1999. Food habits of smallmouth bass, walleyes, and northern pikeminnow in the lower Columbia River basin during out-migration of juvenile anadromous salmonids. Transactions of the American Fisheries Society 128:1036-1054.

Appendix 1: Stanislaus River Species List

Appendix Table 1. Common names, species names, native fish and predator designation, and number of fish captured at Caswell, 2007.

Common Name	Species Name	Native* (Yes or No)	Predator* (Yes or No)	Number Captured
Bigscale Logperch	*Percina macrolepida*	No	No	1
Black Crappie	*Pomoxis nigromaculatus*	No	Yes	1
Bluegill Sunfish	*Lepomis macrochirus*	No	Yes	133
Brown Bullhead	*Ictalurus nebulosus*	No	Yes	4
Channel Catfish	*Ictalurus punctatus*	No	Yes	1
Chinook Salmon	*Oncorhynchus tshawytscha*	Yes	Yes	2,909
Golden Shiner	*Notemigonus crysoleucas*	No	No	3
Goldfish	*Carassius auratus*	No	No	64
Green Sunfish	*Lepomis cyanellus*	No	Yes	2
Hardhead	*Mylopharodon conocephalus*	Yes	No	10
Hitch	*Lavinia exilicauda*	Yes	No	2
Inland Silverside	*Menidia beryllina*	No	No	10
Largemouth Bass	*Micropterus salmoides*	No	Yes	6
Prickly Sculpin	*Cottus asper*	Yes	Yes	11
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*	Yes	Yes	23
Redeye Bass	*Micropterus coosae*	No	Yes	1
Riffle Sculpin	*Cottus gulosus*	Yes	Yes	2
Sacramento Blackfish	*Orthodon microlepidotus*	Yes	No	2
Sacramento Pikeminnow	*Ptychochelius grandis*	Yes	Yes	15
Sacramento Sucker	*Catostomus occidentalis*	Yes	No	104
Smallmouth Bass	*Micropterus dolomieu*	No	Yes	6
Spotted bass	*Micropterus punctulatus*	No	Yes	8
Striped Bass	*Morone saxatilis*	No	Yes	4
Threadfin Shad	*Dorosoma petenense*	No	No	3
Tule Perch	*Hysterocarpus traski*	No	No	28
Western Mosquitofish	*Gambusia affinis*	No	No	148
White Catfish	*Ictalurus catus*	No	Yes	72
White Crappie	*Pomoxis annularis*	No	Yes	25
Unidentified Lamprey	*Lampetra spp.*	Yes	No	502

*Native and predator designations developed from Moyle (2002).

Appendix 2: Fish Health Report

PATHOLOGY REPORT

US Fish & Wildlife Service **phone 530-365-4271**
CA-NV Fish Health Center **fax 530-365-7150**
24411 Coleman Hatchery Rd
Anderson, CA 96007

FHC Case No. : 07-058 **Submittal date: 05/11/2007**
Sample Collector: J. Anderson, cramer assoc.
209-847-7786 phone
Sample Site(s): Stanislaus R, Caswell RST
Histological specimen examiner: J. Scott Foott
Species: Fall-run Chinook smolts **Age: 0-1+**

Tissues:
Four whole fish in sample group. Gill, liver, acinar/pyloric cecae, kidney, lower intestine removed and sectioned

Fixative: Davidson (x) , PREFER-ETOH (), 10%BF ( ), ZFIX ( ), Bouins ( )
Stains: Hematoxylin & eosin (X), PAS ( ), Iron ( )
Block No. 5374-5377 **Block / slide deposition: FHC**

Blood Smear (Number): ND **Bloodsmear Stain: Lieshman-Giemsa ( ), DiffQuick( )**
Clinical chemistry: ND

Summary
Necrotic gills noted upon dissection showed multifocal necrosis associated with mats of bacteria in the sections. **Suspect columnaris (infection by Flavobacterium columnare) as primary health issue.**

No external or internal parasites observed in the tissues (includes T.bryosalmonae). Three of 4 fish with following patterns: diffuse necrosis in liver, intestine, and acinar cells – possible endogenous enzyme digestion artifact due to slow fixation or in the case of the liver a result of hypoxia associated with impaired gill function.

Kidneys were normal.

Appendix 3: List of Abbreviations and Acronyms

AFRP	Anadromous Fish Restoration Program
BOR	U.S. Bureau of Reclamation
CAMP	Comprehensive Assessment and Monitoring Program
Caswell	Caswell Memorial State Park
CDEC	California Data Exchange Center
CDFG	California Department of Fish and Game
CDWR	California Department of water Resources
CFS	Cramer Fish Sciences
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWT	Coded Wire Tag
FL	fork length
ESA	Endangered Species Act
GDW	Goodwin Dam
MKIV	Mark IV Automatic Tag Injector
NMT	Northwest Marine Technology
NTU	Nephelometric Turbidity Units
OBB	Orange Blossom Bridge
PMFC	Pacific Marine Fisheries Commission
QA/QC	quality assurance/quality control program
RIP	Ripon
rkm	river kilometer
RPO	Revised Plan of Operations
RST	Rotary Screw Trap
SWP	State Water Project
T4 Detector	quality control device
Tricaine-S	Trade name for tricaine methanesulfonate
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
VAMP	Vernalis Adaptive Management Plan